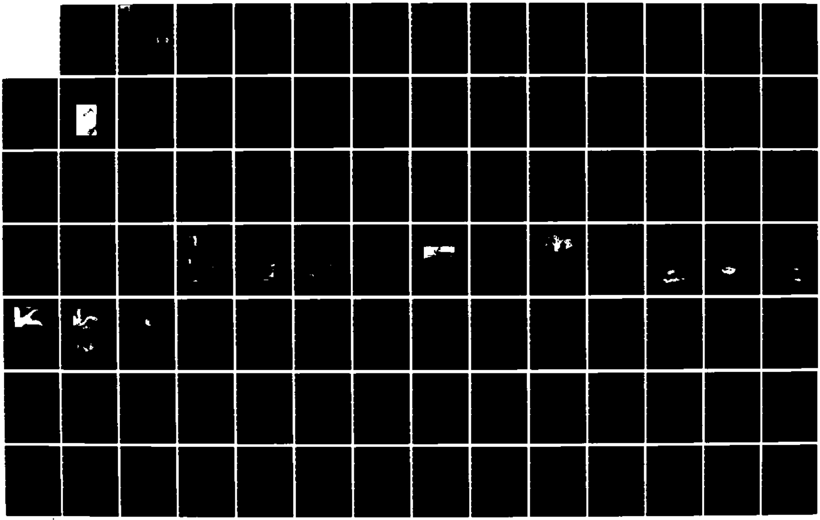
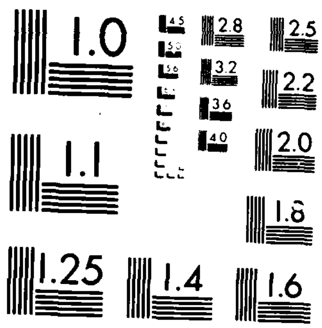
AD-A165 419 OVERSEAS SURVEYS (1981-1983) FOR INSECTS TO CONTROL 1/2
HYDRILLA(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION
VICKSBURG MS ENVIRONMENTAL LAB J K BALCIUNAS DEC 85
UNCLASSIFIED WES/TR/A-85-4 F/G 13/2 NL






MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

US Army Corps
of Engineers

AD-A165 419

AQUATIC PLANT CONTROL
RESEARCH PROGRAM

TECHNICAL REPORT A-85-4

# FINAL REPORT ON THE OVERSEAS SURVEYS (1981-1983) FOR INSECTS TO CONTROL HYDRILLA

by


Joseph K. Balciunas

Aquatic Plant Management Laboratory
University of Florida/US Department of Agriculture
Fort Lauderdale, Florida 33314




December 1985

Final Report

Approved For Public Release; Distribution Unlimited




Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

Monitored by Environmental Laboratory
US Army Engineer Waterways Experiment Station
PO Box 631, Vicksburg, Mississippi 39180-0631


86 9

## US DEPARTMENT OF AGRICULTURE/
## CORPS OF ENGINEERS
## COOPERATIVE AQUATIC PLANT CONTROL RESEARCH

| | |
|---|---|
| Annual Report for FY 1981, Biological and Chemical Control Technology | MP A-83-9 |
| Annual Report for FY 1982, Biological and Chemical Control Technology | MP A-84-2 |
| Annual Report for FY 1983, Chemical Control Technology | MP A-85-3 |
| Final Report on the Overseas Surveys (1981-1983) for Insects to Control Hydrilla | TR A-85-4 |

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>Technical Report A-85-4 | 2. GOVT ACCESSION NO.<br>AD-A165419 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>FINAL REPORT ON THE OVERSEAS SURVEYS (1981-1983) FOR INSECTS TO CONTROL HYDRILLA | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Joseph K. Balciunas | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Department of Agriculture, University of Florida/Aquatic Plant Management Laboratory, 3205 College Ave., Fort Lauderdale, Florida 33314 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Aquatic Plant Control Research Program |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>DEPARTMENT OF THE ARMY, US Army Corps of Engineers, Washington, DC 20314-1000 | | 12. REPORT DATE<br>December 1985 |
| | | 13. NUMBER OF PAGES<br>93 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)<br>US Army Engineer Waterways Experiment Station Environmental Laboratory<br>PO Box 631, Vicksburg, Mississippi 39180-0631 | | 15. SECURITY CLASS. (of this report)<br>Unclassified |
| | | 15a. DECLASSIFICATION DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aquatic plant control
Aquatic weeds
Biological control
Hydrilla
Insects

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The geographic area of origin for the noxious exotic weed, hydrilla (*Hydrilla verticillata*), has not been pinpointed. Three extended collecting trips to Asia and Australia where hydrilla is considered to be native were made to catalog the natural enemies of this plant. During the 15 months spent overseas during these surveys, the strategy was to collect at as many different sites as time and funding would permit. Unlike in the United States, hydrilla

(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued).

rarely forms dense monocultures in these areas, and it was frequently difficult to locate. The lack of competitiveness and "weediness" by hydrilla in its native range is probably due, in most instances, to the action of natural enemies. These three surveys yielded 180 collections containing over 45 insect species which attack hydrilla. All 45 of these insects are either weevils, ephydrid flies, or aquatic moths, groups which are known to be herbivorous and host-specific. Insects which only occasionally damage hydrilla, such as caddisfly and midge larvae, are not included in the list. More intensive surveying would also multiply this number of candidate species. Compared to the handful of insect species found attacking hydrilla in the United States during an intensive multiyear survey, it is apparent that hydrilla in the United States is depauperate in natural enemies. This helps to account for hydrilla's rapid displacement of native plants in the United States. Since native competitors are absent, introduced biological control insects would have a high chance of becoming established in the United States. The control of hydrilla in the United States by introduced exotic insects now appears more probable, and the hydrilla biological control project should be intensified. Achieving a level of hydrilla control comparable to that observed overseas will probably require the introduction of a complex of insects (including leaf-miners, defoliators, stem-borers, and tuber feeders). The long-term nature and multispecies approach should be incorporated into the planning and funding of the hydrilla biocontrol project. The screening for possible introduction into the United States of insects already found during these surveys has begun and will continue. However, a more complete list of hydrilla's natural enemies is required to allow sound decisions in the future. This would require expanding the searches to areas not yet surveyed and conducting more intensive searches at the more promising of the areas previously visited. These areas, along with additional recommendations, are listed in this report.

## PREFACE

The primary source of funding for this project has been the Aquatic Plant Control Research Program (ARPCP) of the US Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss. The US Department of Agriculture's Agricultural Research Service (USDA-ARS) has also provided substantial financial support along with technical equipment and support. The University of Florida's Fort Lauderdale Research and Education Center provided the office space and the basic administration for this project. Funds provided by USDA's Far Eastern Regional Research Organization (FERRO) allowed for an additional several months of research in India. This report was written by Dr. Joseph K. Balciunas, University of Florida, Fort Lauderdale, Fla.

Many officials within these organizations were personally involved in the preparations and planning for these trips. I would like to thank the following for their advice and assistance: USDA--Drs. Gary Buckingham, Ted Center, Dean Davis, and Bill Larson; University of Florida--Mr. Dave Bryant and Dr. W. B. Ennis; WES--Dr. Al Cofrancesco and Mr. Ed Theriot; FERRO--Drs. Jack Lipes and Dick Parry.

The success of these trips was due to a great extent to the cooperation of many people located in these countries. I would like to thank the individuals from these multinational and international organizations which provided assistance: United Nations Food and Agricultural Organization: Dr. Terry Crowe (Burma), Dr. John Lowe (Thailand), Dr. Peter Kenmore (Philippines), and Dr. Phil Thomas (Papua New Guinea); Commonwealth Institute of Biological Control--Dr. Fred Bennett (Trinidad), Dr. T. Sankaran and Mr. Nair (India); Commonwealth Industrial and Scientific Organization--Drs. Ken Harley and Don Sands, and Mr. Tony Wright (Australia).

Individuals at the American embassies in many countries provided valuable advice and assistance: in India - Drs. Jim Smith and Stanley Stone, and Mr. Mahay (all with FERRO); in Burma - Messrs. Eugene Dorris, Ed Goff, Hugh MacDougall, John Htin Aung, and U Saw Laik; in Malaysia - Messrs. Richard Blabey and Raymond Ho; in Indonesia - Messrs. Dan Conable and Allan Trick.

I would also like to thank the many other overseas scientists and officials who graciously provided me with assistance: Australia - Messrs. John Gillett and Ian Miller; Indonesia - Mr. Aderis, Mr. Roland Barkey, Dr. Karrandi, Mr. Kasno, Dr. Kosterman, and Dr. Nengah; Malaysia - Dr. Ivor Caunter; Papua New Guinea - Drs. John Ismay, Greg Leach, Paddy Osborne, Jim Dees, Francis Dubonai, and Hosen P. John; Philippines - Dr. Bob McAmis, Juan Pancho, Ray Valesco, and Bob Vore; Sri Lanka - Dr. Stanley Gunasakera and Mr. Bowie; Thailand - Dr. Banpot Napompeth.

My thanks to Dr. C. D. K. Cook for providing me with the list of hydrilla herbarium records; Dr. Charlie O'Brien for identifying the weevils; Dr. Dale Habeck, Dr. Don Sands, and Mr. Marc Minno for identification of moths; and Dr. D. Deonier for identifying the ephydrid flies. I would also like to thank my assistants, Mr. Mark Minno and Mr. Allen Dray, and my technicians, Ms. Mary Cabot, Mr. Ray Dranoff, Ms. Eileen Flannigan, Ms. Michele Griffin, Mr. Ron Micklas, and Ms. Donna Newman, who assisted before, during, and after these trips. My thanks to Ms. Bev Benner for the maps and, finally, my special thanks to Ms. Debbie Spurgeon for taking care of the mountains of paperwork preceding and following each trip and for typing this manuscript and previous reports.

The principal investigator at WES for the work contained in this report was Mr. Edwin A. Theriot assisted by Dr. Alfred F. Confrancesco. Mr. J. Lewis Decell was Program Manager, APCRP. Dr. John Harrison was Chief, EL. The Technical Monitor for Office, Chief of Engineers, was Mr. E. Carl Brown. The report was edited by Ms. Jamie W. Leach of the WES Publications and Graphic Arts Division.

Director of WES was COL Allen F. Grum, USA. Technical Director was Dr. Robert W. Whalin.

This report should be cited as follows:

Balciunas, J. K. 1985. "Final Report on the Overseas Surveys (1981-1983) for Insects to Control Hydrilla," Technical Report A-85-4, prepared by US Department of Agriculture, Fort Lauderdale, Fla., for the US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

CONTENTS

CONTENTS

LIST OF FIGURES

# FINAL REPORT ON THE OVERSEAS SURVEYS (1981-1983) FOR INSECTS TO CONTROL HYDRILLA

## PART I: INTRODUCTION

### Purpose and Scope of Present Study

1. Since its establishment in the United States some 25 years ago, the exotic macrophyte hydrilla (*Hydrilla verticillata*) has spread rapidly and now has become one of the most troublesome aquatic weeds in the United States. The purpose of this study was to provide a list of hydrilla's natural enemies which occur overseas. The geographical scope of these surveys was South Asia (India, Burma, and Sri Lanka), Southeast Asia (Thailand, Malaysia, Indonesia, and Philippines), and tropical Australia and Papua New Guinea. Some of the insects found damaging hydrilla during these surveys may prove useful in controlling hydrilla in the United States. Several species collected during these surveys are now being tested at the quarantine facilities in Gainesville, Fla. Overseas evaluations of additional species are planned.

### Hydrilla's Introduction into the United States

2. Hydrilla was a popular aquarium plant, usually sold as "star-vine" or "oxygen-plant," in the United States for decades. A big factor in this popularity is hydrilla's ability to survive at the low light levels typically found in home aquaria. Aquarium plant dealers colonized hydrilla in order to have a cheap, local source for this popular plant. By the late 1950's or early 1960's, hydrilla had "escaped" into several natural aquatic systems in Florida and was becoming a nuisance. The earliest US specimen of hydrilla seen by this author was collected in October 1962 at Big Lake Conway in Orlando, Fla. Hydrilla may have been present in Central America prior to its establishment in Florida. Hartog (1973, p 9) states, "The records from Panama are the first from the Americas," but unfortunately does not provide the date. The spread of this plant throughout the United States during the last 25 years has been explosive. It is currently found in Alabama, California, Delaware,

Florida, Georgia, Louisiana, Maryland, North Carolina, South Carolina, Texas, Virginia, and the District of Columbia (Haller 1982).

## Distribution and Origin of Hydrilla

3. Hydrilla is now almost cosmopolitan in its distribution. Antartica and South America are the only continents from which it has not yet been recorded. It is very common on the Indian subcontinent, many of the Middle East countries, Southeast Asia, and northern and eastern Australia. Based on C.D.K. Cook's (personal communication) list of hydrilla herbarium specimens, it is found in the southern hemisphere as far south as North Island of New Zealand at a latitude of approximately 40°. In the northern hemisphere it is found as far north as Ireland, England, Poland, and Lithuania. The Lithuanian sites, at about 55° latitude, are the furthest from the equator that hydrilla is known to occur. Since virtually all of the continental United States lies below a latitude of 48°, hydrilla is climatically suited for growth in any of the 48 contiguous states as well as Hawaii. Even Alaska cannot be considered entirely safe from invasion by hydrilla since places such as Juneau and Ketchikan are at approximately the same latitude as the hydrilla infestations in Lithuania.

4. The area of origin of *Hydrilla verticillata* is far from clear. Cook and Luond (1982, p 490), along with many other botanists, feel that "...its centre of origin lies in the warmer regions of Asia." However, hydrilla has been in central Africa for a long time--it was collected by Speke during his 1860-1863 expedition to find the sources of the Nile (Speke 1864)--and some botanists believe that it originated there (Tarver 1978). Mahler (1979 p 5) is even more precise, stating "...with a center of distribution or origin in southeastern Uganda and northwestern Tanzania." Hydrilla is also considered by some to be native to Australia (Sainty and Jacobs 1981). The first records from Australia are from the early portion of the nineteenth century, soon after the first white settlers arrived in Australia.

5. Determining the area of endemism is extremely important in biological control programs since the center of origin is usually considered to be the prime area to begin searches for natural enemies. With the lack of persuasive evidence to pinpoint hydrilla's origin, searches will have to be made in Africa, Asia, and Australia.

## Ecology

6. Hydrilla has very wide ecological amplitude, growing in a variety of aquatic habitats. It is usually found in shallow waters, 1/2 m or greater in depth. In very clear waters it can grow at depths exceeding 10 m. It tolerates moderate salinity, up to 33 percent of seawater (Mahler 1979). While it flourishes best in calcareous waters, water quality rarely seems to be limiting since it is found in both acidic and alkaline waters. It also grows well in both oligotrophic and eutrophic waters, and even tolerates high levels of raw sewage (Cook and Luond 1982). While hydrilla does not grow well in deeply shaded areas, it is adapted to grow under very low light conditions (Bowes 1977) and this may account for its rapid growth and quick dominance over native vegetation.

7. Hydrilla is usually a gregarious plant and frequently forms dense, intertwined mats at the surface. Approximately 20 percent of the plants' biomass is concentrated in the upper 10 cm of such a mat (Haller and Sutton 1975). The plants grow and spread quickly with small fragments of the plant, containing but a single node, quickly developing adventitious roots and eventually producing an entire plant. Hydrilla fragments on recreational boat trailers appear to have been the mode of infestation of many new aquatic systems in Florida.

## Economic Importance

8. Hydrilla has spread rapidly since its introduction into the United States less than 25 years ago. Burkhalter (1977) states that by 1965, 10,000 acres* were infested by hydrilla in Florida. This had increased to 50,000 acres by 1970, and to 500,000 acres by 1977. Approximately 200,000 of these half-million acres were "topped-out" hydrilla.

9. Severe infestations of hydrilla impede water flow, hamper irrigation and flood control efforts, and restrict navigation and recreation. Drownings have occurred when swimmers became intangled in hydrilla. Properties

---

* To convert acres to square metres multiply by 4046.873.

adjoining infested areas have their values depressed. Guerra (1977) reports that the economic losses due to the presence of hydrilla in a single, medium-sized, Texas lake (Lake Conroe) exceeded $30 million.

10. The most visible of the costs entailed by the presence of hydrilla is the cost associated in attempting control. In excess of $8 million is spent annually in the state of Florida alone on hydrilla control (Mahler 1979). With costs for chemical and mechanical control usually exceeding $200 per acre, and with several treatments usually required during the growing season, only high priority waters can be effectively managed.

## Taxonomy

### Identification difficulties

11. Hydrilla has been recognized as a separate species of plant since the early days of taxonomy. According to Cook and Luond's (1982) synonomy, Linnaeus' son published a figure of it (described as *Serpicula verticillata*) in 1781. In 1839, Royle was the first to correctly call it *Hydrilla verticillata*. However, throughout the nineteenth century, it was frequently placed in other aquatic genera such as *Udora*, *Elodea*, and *Vallisneria*, and many additional species and "varieties" of *Hydrilla* were described in the literature. Most of the variation in the morphology of the leaves and stems, which caused the proliferation of *Hydrilla* species and variety names, is now known to be due to environmental factors. Thus, even though the chromosome number is not identical for all populations (i.e., polyploidy is evident), *Hydrilla* is currently considered a monotypic genus, containing only the species *verticillata* (Cook and Luond 1982).

12. Hydrilla is frequently misidentified when it first appears in a new area. When hydrilla first started becoming a problem in Florida in the early 1960's, it was called Florida elodea, reflecting the opinion that this was a new species or variety of *Elodea*. It has also frequently been confused with still another member of the family Hydrocharitaceae--*Egeria*. When flowering, these three genera are easily distinguished, but botanists will usually refrain from positively identifying sterile material. Persons with extensive field experience with hydrilla can usually reliably identify sterile plants even in the field. In the laboratory, the presence of small spines along the

leaf margins, along with fingerlike projections on the nodal scales, can be used to confirm identifications of sterile hydrilla.

Description

13. Hydrilla (Figure 1), *Hydrilla verticillata* (L.f.) Royle, is a perennial, submerged, rooted, vascular plant. It is placed in the family Hydrocharitaceae. Other members of this family commonly found in the United States include *Egeria*, *Elodea*, and *Vallisneria*.

14. Roots are long, slender, and simple, whitish or light brown in appearance. They are usually buried in hydrosoil, but also form adventitiously at nodes. Stems are long, usually branching, growing from the hydrosoil and frequently forming dense, intertwined mats at the surface of the water. Detached portions of hydrilla plants remain viable and are a common mode for infestation of new areas. Below the hydrosoil, the stems are horizontal,

Figure 1. Typical hydrilla (*Hydrilla verticillata*) plant. Note tubers at end of stolons

creeping, and stoloniferous. Leaves are opposite, usually occurring in whorls and normally numbering three to five per node. Apical portions of the stem usually have the nodes tightly clustered and bearing up to eight leaves. The leaves are usually strongly serrated with the teeth visible to the naked eye and each leaf terminates in a small spine. The midvein is sometimes reddish in color and is usually armed with an irregular row of spines. The squamulae intravaginales (nodal scales) are small (ca. 0.5 mm long) paired structures at the base of the leaves, and are lanceolate, hyaline, and densely fringed with fingerlike, orange-brown structures which are usually unicellular, although sometimes bicellular. Two types of hibernacula are produced--a brown, bulb-like type is produced at the ends of stolons, while a green, conical form is found in axils of branches. In the United States, the former are usually called tubers and the later turions. Flowers are imperfect (unisexual) solitary, enclosed in spathes. The female flower is white, translucent, three sepals, broadly ovate, about 1.2 to 3.0 mm long; the three petals alternate with the sepals which are much narrower and slightly shorter; the three stigmas are minute; the ovary is at the base of the long (1.5 to 10+ cm) hypanthium. The male flower is solitary in leaf axils. Mature flowers abcise and rise to surface. Sepals and petals are similar in size and shape to those of female flowers. Each of three stamens bears a four-celled anther which produces copeous, minute, spherical pollen. Fruits are cylindrical, about 5 to 10 mm long, usually with long, spinelike lateral processes. Seeds are smooth, brown, usually five or less, 2 to 3 mm long, borne in single linear sequence.

## Chemical Control

15. Managers of aquatic systems infested by hydrilla usually need effective, quick-acting results. For this they usually rely on herbicides. A great variety of chemicals, including concentrated solutions of sulfuric acid (Phillippy 1967), ammonia (Ramachandran 1960), and hydrogen peroxide (Quimby 1981), have been tried. Pieterse (1981) provides a thorough review of the extensive literature on controlling hydrilla with chemicals. Currently, the most commonly used herbicides for hydrilla control are diquat and endothall. These are frequently combined with copper formulations to increase their

efficacy and various copper complexes are occasionally used by themselves for hydrilla control.

16. The drawbacks to the use of herbicides are well known. Serious environmental consequences may result from placing such chemicals directly in aquatic systems. Not only may nontarget organisms, such as fish and invertebrates, be adversely affected, but also the potability of the water and its use for irrigation and swimming is usually temporarily imparied. The dead, decaying plant material may also adversely affect water quality. Although the careful use of approved herbicides can overcome or at least ameliorate most of these problems, many countries (and a few states in the United States) severely restrict or prohibit the use of herbicides in aquatic systems.

17. Another factor limiting the use of herbicides is their cost. At $200 or more per acre per treatment, only high-use, high-priority waters can usually be treated.

## Mechanical Control

18. In most developing countries, hydrilla (along with other nuisance aquatics such as waterhyacinth) is simply manually removed from the water. In more developed countries with their high labor costs, specially designed machines for harvesting submersed vegetation are sometimes employed.

19. Mechanical harvesting overcomes many of the environmental problems encountered when using herbicides. When the use of herbicides is restricted for legal or environmental reasons, mechanical harvesting is frequently the method of choice for achieving temporary control in small lakes or portions (e.g. fishing trails) of larger lakes. Unfortunately, the cost of mechanical control of hydrilla is frequently more expensive than using herbicides with the actual cost being highly dependent on the distance the harvested hydrilla must be transported for disposal. McGehee (1979) reports costs of $1,122 per hectare ($454/acre) when the hydrilla cuttings were placed back into a different portion of Orange Lake in north-central Florida. While the area used for disposal at Orange Lake was virtually 100 percent infested with hydrilla, hydrilla fragments might root and form new plants, thus compounding the problem in aquatic systems with sparser or patchier hydrilla distributions.

## Biological Control

### Advantages

20. Both chemical and mechanical measures for controlling hydrilla are expensive and usually require multiple treatments during the growing season. Environmental concerns are restricting the use of herbicides and the "loss" of approval for use of commonly used chemicals is greater than the rate that "new" compounds are approved for aquatic weed control. Accordingly, the use of living organisms that consume or otherwise stress hydrilla is receiving increased attention.

21. Modern usage of the term "biological control" refers to the use of living organisms to suppress population levels of a pest. Among other things it includes the use of innundative releases of endemic natural enemies, releases of sterilized pests, and enhancing the action of natural enemies. Some authors would also include certain cultural practices such as drawdowns, and the use of host-resistant varieties as being biological control practices. Initially, the term "biological control" was more restrictive, describing the process of establishing introduced, foreign organisms to control an imported pest. The term "classical biological control" is now used to described this traditional approach of reassociating a foreign pest with its natural enemies (usually insects) from its native range. An ideal biological control agent is highly specific, damaging only the target pest (and possibly a very limited number of other hosts), and, once established, maintains population levels high enough to control the target pest.

### Fish

22. The use of fish as biological controls for hydrilla has received a great deal of attention. This concentration of effort has been primarily due to the ready availability of the grass carp (also called the while amur), *Ctenopharyngodon idella* Val. This large, herbivorous fish consumes enormous amounts of aquatic vegetation. While it will feed on almost any vegetation, including terrestial vegetation, that comes in contact with water, hydrilla is a preferred food. Grass carp are apparently effective in keeping small, enclosed aquatic systems free of hydrilla. The fish were once considered to be unable to breed successfully in US waters, but this assumption has since been proven incorrect (Pierce 1983).

23. Sutton (1977) reports that grass carp are banned in Canada and in 26 states of the United States. Apparently, this is due to fears of the possible impact of this large, imported fish on native fisheries. There has also been some concern that phytoplankton "blooms" will occur once the grass carp have consumed the macrophytes (Ewel and Fontaine 1982). Osborne and Sassic (1979) indicate that this has not occurred at the release sites they studied.

24. Recently, in order to overcome objections to the possible reproduction in the field by grass carp, there has been a large amount of research into the hybrid grass carp, the sterile offspring of crossing a female grass carp and a male bighead carp, *Hypophthalmichthys nobilis* Rich. However, it appears that the hybrid is not nearly as effective as the grass carp. Osborne (1982), in his studies of the hybrid carp in eight Florida lakes, concluded that it was ineffective in controlling hydrilla due to high mortality and extremely low feeding rate. Current grass carp research is centered on the use of triploid and surgically sterilized fish.

25. *Tilapia zillii* (Gervais) also consumes hydrilla (Legner 1979), but this fish is much smaller and does not damage hydrilla nearly as much as the grass carp.

Other noninsects

26. The snail, *Marisa cornuarietis*, consumes hydrilla and has been considered for use as a biological control agent. However, large numbers are necessary to achieve control, and *Marisa* is not completely specific, feeding on, among other things, young rice plants (Blackburn, Boyer, and Timmer 1971).

27. Manatee, *Trichechus manatus* L., consumes enormous amounts of aquatic vegetation, including hydrilla (Campell and Irvine 1977). However, this is an endangered species and any direct contact with the animal is illegal, making it impractical for use in management programs.

28. Several pathogens have been found on hydrilla, of which *Fusarium roseum* 'Culmorum' has shown the most virulency (Charudattan 1980). However, this virulence is difficult to demonstrate in larger containers (Charudattan 1983).

Previous successes with insects

29. During the past 100 years, the classical approach to biological control has been very successful in controlling a wide variety of terrestrial weeds and insect pests. Classical biological control programs have also been

successful in controlling several aquatic weeds. Alligatorweed, *Alternanthera philoxeroides*, has successfully been controlled in the United States by the beetle *Agasicles hygrophila* and two other insect species, all imported from Argentina. It also appears that waterhyacinth, *Eichhornia crassipes*, is being controlled in Louisiana and several other US locations by two Argentine weevils, *Neochetina* species, and that the recently released Argentine moth, *Sameodes albigutalis*, is impacting waterhyacinth at some of its early release sites in Florida. In Australia, along with successes in controlling the above-mentioned aquatic nuisances, the control of *Salvinia molesta* by the South American weevil, *Cyrotobagous singularis*, has been reported at several locations (Room et al. 1981).

#### Domestic search for insects damaging hydrilla

30. Any thorough, well-conceived pest control program should consider the natural enemies already stressing the pest. Between July 1978 and August 1980, the author conducted a survey of the macroinvertebrates associated with hdyrilla in the United States. A total of 285 collections at 76 sites resulted in 59,010 macroinvertebrate specimens. Of these, 17,358 (29.4 percent) were insects representing 191 species. A complete listing of the collection sites, species collected, etc., can be found in Balciunas and Minno (1984). The insects which caused the most damage were the larvae of aquatic moths with *Parapoynx diminutalis* and *Synclita obliteralis* being the most common. *Parapoynx diminutalis*, an Asiatic species accidentally introduced into the United States, was the only insect showing a preference for hydrilla in the field. The midges (Diptera:Chironomidae) and leptocerid caddisflies (Trichoptera:Leptoceridae) were frequently numerous on hydrilla but only occasionally caused damage.

#### Previous efforts to locate foreign insects for control of hydrilla

31. Not long after hydrilla was correctly identified and its pest potential became evident in Florida, interest in finding a foreign insect to control it began to increase. Rather than establishing a foreign laboratory, the more economical approach of contracting foreign scientists to conduct most searches, along with short overseas trips by US scientists, was the strategy employed. Appendix A briefly lists these foreign searches for hydrilla

insects. Unfortunately, many of these studies were of short duration, not very thorough, and therefore not very productive.

32. During the late 1960's, hydrilla was one of the minor aquatic weeds on a long list of aquatic plants whose natural enemies were surveyed in India by Commonwealth Institute of Biological Control (CIBC) scientists. Of the several *Nympula* moths found on hydrilla, *Parapoynx diminutalis* was the most damaging and widespread (Rao 1969, Rao and Sankaran 1974).

33. The longest and most thorough of the foreign studies was the US Department of Agriculture (USDA) sponsored project conducted by CIBC scientists in Pakistan between 1971 and 1976. Of the 10 insects and 2 snails found damaging hydrilla during this survey--a moth, *Parapoynx* (Nymphula) *diminutalis*; three *Bagous* spp. weevils; and an ephydrid fly, *Hydrellia* sp. D--showed the most promise as potential biocontrol agents (Ghani 1976).

34. In the early 1970's, Dr. George Allan of the USDA Agriculture Research Service (ARS) and University of Florida made several short trips overseas and directed some effort at establishing hydrilla surveys with cooperating foreign scientists. It appears that only a US-AID*/University of Florida project in Malaysia was completed. This project focused on pathogens, and the limited field surveys for insect enemies revealed only the moth *Parapoynx diminutalis*, while aphids were found on the laboratory cultures of hydrilla (Varghese and Singh 1976).

35. In 1976, US scientists Robert Pemberton and Robert Lazor, under contract with USDA-ARS and US Army Corps of Engineers, conducted a survey for natural enemies of hydrilla in Eastern Africa. Hydrilla was not located until the latter portion of the trip, and of the few insects found to be possibly damaging hydrilla, the chironomid midge, *Polypedilum* sp., was thought to be most promising (Pemberton 1980).

36. In 1980, tests of a South and Central American moth species damaging hydrilla were conducted in Panama and this *Parapoynx* species was found to be fairly specific to hydrilla (Balciunas and Center 1981). Permission to bring this moth into Gainesville quarantine facilities was eventually obtained, but three subsequent collecting trips have failed to find this tested species, which was common in 1980.

* US-AID = US Agency for International Development.

Status of exotic insects
for control of hydrilla

37. Currently the only foreign insect damaging hydrilla in the United States is the Asian moth, *Parapoynx diminutalis*. A native of tropical Asia, this moth was first discovered in Florida in the mid-1970's (Del Fosse, Perkins, and Steward 1976). *Parapoynx diminutalis* was probably accidentally introduced into the United States in a shipment of aquarium plants. It has spread rapidly throughout Florida since its discovery and is already negatively impacting hydrilla at some sites (Balciunas and Habeck 1981). Those in charge of managing hydrilla-infested aquatic systems would be wise to consider the potentially devasting defoliation of hydrilla caused by this new member of the US insect fauna.

38. The most thorough of the foreign surveys, by CIBC in Pakistan, noted a complex of at least 10 insects damaging hydrilla. The most promising of these, the tuber-feeding *Bagous* weevil and the leaf-mining *Hydrellia* fly, deserve to be evaluated in US quarantine facilities to confirm their potential as biological control agents. The few insects found during the other foreign surveys are probably the result of their limited geographic scope, short duration, and/or superficial nature. It would be rash to assume that additional insects damaging hydrilla do not exist, not only at locations which were never searched but also in areas which were only briefly or perfunctorily surveyed.

39. A comparison with the previous, successful projects to find insects to control aquatic weeds may put these scattered efforts in perspective. The successful programs to find insects to control alligatorweed and waterhyacinth entailed the establishment of a laboratory in Argentina continuously staffed for more than 10 years by two scientists. Even with this intensive effort, it took more than 10 years from the time the first insect for controlling waterhyacinth was discovered in Argentina, until it was first released in the United States. The main drawbacks to establishing a classical biological control program of hydrilla are the high cost of the exploration and testing to find a proper insect species, and the long periods of time necessary to locate, test, release, and establish the species as a biological control agent. For these reasons, the level of interest (and funding) for locating an insect to control hydrilla has been fairly low.

## PART II: METHODS AND MATERIALS

### Pretrip Preparations

40. Of considerable help on the initial trip were the questionnaires sent to various foreign scientists by Dr. Gary Buckingham (USDA-ARS, Gainesville) in 1980 (see Appendix B). While relatively few responses were received, they were helpful in indicating the costs of conducting research in a particular country, the type of facilities which might be expected, and the most appropriate time to conduct research there.

41. During a 1981 visit with Dr. C. D. K. Cook in Zurich, he graciously provided a listing of the collection localities for the numerous hydrilla herbarium specimens he had assembled from around the world. This listing of locations of verified hydrilla specimens proved to be very useful in choosing general areas and specific locations to be visited in search of hydrilla-damaging insects.

42. Once a country was chosen for surveys, lines of communication were established, if possible, with officials and scientists residing there. The process of acquiring the proper visas, obtaining tickets and cash advances, filling out the paperwork required by various funding agencies, and assembling the equipment which would be used during the trip also began early. Because of the unavailability of even the most basic supplies in remote areas, the amount of collecting and laboratory supplies carried was considerable, usually weighing about 60 to 70 kg. Transporting and maintaining security over this much equipment was a constant, high priority, logistical problem. These trips each required about 3 months of full-time preparation.

### Overseas Preparations

43. Upon arriving in a foreign country (usually the capital city), the foreign scientist or official with whom the author had been corresponding was contacted. Up-to-date information on weather conditions, most recent collections of hydrilla, areas of insurgent activity, etc., was obtained. In some countries the author had to secure collecting permits, permission to enter and collect in certain areas, export permits for the specimens, etc.

44. Arrangements for travel to more distant sites were then made. The usual strategy was to take public transportation (airline, if possible) to the city or major town closest to the intended collecting site. From there, especially if the intended collecting site was in a remote area, a car and driver were hired.

45. Upon arrival at the site, local residents and fishermen were questioned about the presence of hydrilla. Sketches, photographs, and/or herbarium specimens greatly assisted in this questioning. Fishermen were usually quite knowledgeable as to which plants were in the vicinity. If the site was large and productive enough to support fishermen, a boat could be hired with relative ease for further surveying and collecting. At other sites, the aquatic vegetation was surveyed from shore using binoculars. If close to shore, the hydrilla was collected by means of a double-headed rake on the end of a 15-m rope. Otherwise, the hydrilla was collected by wading or swimming. This was the least preferred method due to the many water-borne diseases (i.e., shistosomiasis, cholera, typhoid) and to the possible presence of dangerous aquatic animals such as crocodiles.

## Types of Collections

46. Insects associated with hydrilla were collected by three different techniques. The most common technique was to collect hydrilla with a rake or by hand and then search each individual piece of hydrilla and remove any fauna encountered. The damage to hydrilla would be noted and sometimes the organism causing the damage could be detected. Other personnel, when available, could be trained relatively easily to assist in this hand searching, and this technique could be used at all hydrilla infestations. The main drawbacks were that this procedure was tedious and time-consuming (at least 3 to 4 hr is required to search though a single, 1/2-kg sample of hydrilla) and that fairly good lighting was required.

47. The second collecting technique was to set up a battery-powered 15-w ultraviolet (UV) light in front of a vertical white bed sheet hanging near the water's edge. Frequently, large numbers of aquatic insects would be attracted and those of interest could be easily collected. However, it was not possible to associate a particular insect species collected at the UV light with its host plant. The UV light collections did allow collecting

large numbers of adults (especially of moths, *Bagous* spp. weevils, and *Hydrellia* spp. flies) whose larvae were known to damage hydrilla. These UV light collections were also a quick way of assessing the number of potential hydrilla-damaging insect species present at a particular location. Unknown *Bagous* spp. weevils collected in this manner were usually exposed for a few days to a fragment of hydrilla in a small cup to ascertain if they fed on hydrilla. Besides the lack of host plant information, UV light collections also had several other disadvantages. Insects were attracted to the UV light in large numbers in the first few hours after sunset, but only if the moon had not yet risen. Thus, UV light collections were limited to the first few hours of darkness during the 2 weeks between full moon and new moon. Windy or rainy weather further limited nights on which UV light collections could be made. In remote areas, travel to the sites at night was difficult to arrange. In areas of high insurgent activity, it was considered highly imprudent for foreigners to venture at night from hotels protected by government troops.

48. The third method of collecting was to place hydrilla in a berlese funnel and capture the fauna emerging from the plant material as it dried out. An incandescent lamp bulb (usually 15 to 25 w) was used as a heat source in the top portion of the berlese funnel. Many different insect groups could be collected this way, but it was especially useful in finding those that burrow in the stem, such as the *Bagous* weevils and *Hydrellia* fly larvae. The major drawback to this collecting technique was that it required a reliable source of electricity during the 3 to 4 days the sample was drying. This requirement was impossible to meet at many of the more remote collecting areas where electricity, if any was available, was only generated during nighttime hours. Even in some major urban areas, frequent brownouts and blackouts caused loss of samples or modifications (usually smaller samples and/or hotter bulbs) to the technique.

## Specimen Handling and Identification

49. All insects (except adult moths) collected during these surveys were preserved in 75 percent isopropyl or ethyl alcohol. Soft-bodied insects were first placed in hot (near boiling) water in order to prevent the distortion and discoloration common when such specimens are placed directly in alcohol. A small sterno stove served as a heat source in the field. Adult

moths were placed in a cyanide killing jar, and, once dead, layered between tissue paper in crush-resistant containers. All specimen containers (vials, boxes, etc.) were labelled with the appropriate collection number unique to a particular site and time.

50. Voucher herbarium specimens of hydrilla and other plant species used for tests and collections were also made.

51. Biological specimens were shipped back to United States from the country where they were collected in order to avoid the problems with transporting specimens into and out of each of the many countries visited during a single trip. Most shipments were air mailed although some were sent back via US Embassy mail facilities.

## Data Recording and Analysis

52. At each site, environmental conditions associated with the collection were recorded on a field data sheet (see Appendix C). Among data recorded were date, time of day, depth, percentage cover, salinity, water temperature, and conductivity, along with brief descriptions of the site, other aquatic plants, insect damage, and weather.

53. After returning to Florida, most of these data, along with the identifications of the insects and other animals, were entered on the DEC PDP-11/34 computer at the University of Florida Research and Education Center in Fort Lauderdale. Data files were manipulated and analyzed statistically using SAS statistical package resident on the main frame computer at the North East Regional Data Center in Gainesville, Fla.

## Identifications

54. The author was able to identify most insects to family level at the time they were collected in the field, and usually to identify to genus and sometimes to species those herbivorous insects which had been collected on previous trips. Field identifications were confirmed at the hotel or field laboratory by examining the specimens under a microscope.

55. After the specimens arrived in the United States, they were sorted, counted, and representative specimens of the herbivorous groups sent to appropriate experts. A serious drawback was that many, perhaps even the

majority, of these insects are new to science, and these new species will have to be described by experts. The nonherbivorous insects and other aquatic fauna were identified to the lowest possible taxon by technicians, especially Mr. Marc Minno.

## PART III: RESULTS

56. Three trips, each from 4-1/2 to 6 months in duration, were made to Asia and Australia in search of insects with potential as biocontrol agents for hydrilla. The focus of the first trip was Indonesia, especially the islands of Java and Sumatra, along with short stops in India, Burma, Thailand, and Malaysia. The general route of this 1981 trip is depicted in Figure 2 and a log of the trip can be found in Appendix D. The second trip in 1982 lasted for 6 months and focused on testing weevils in India, although most of the 1981 sites were revisited along with collections at many additional sites.

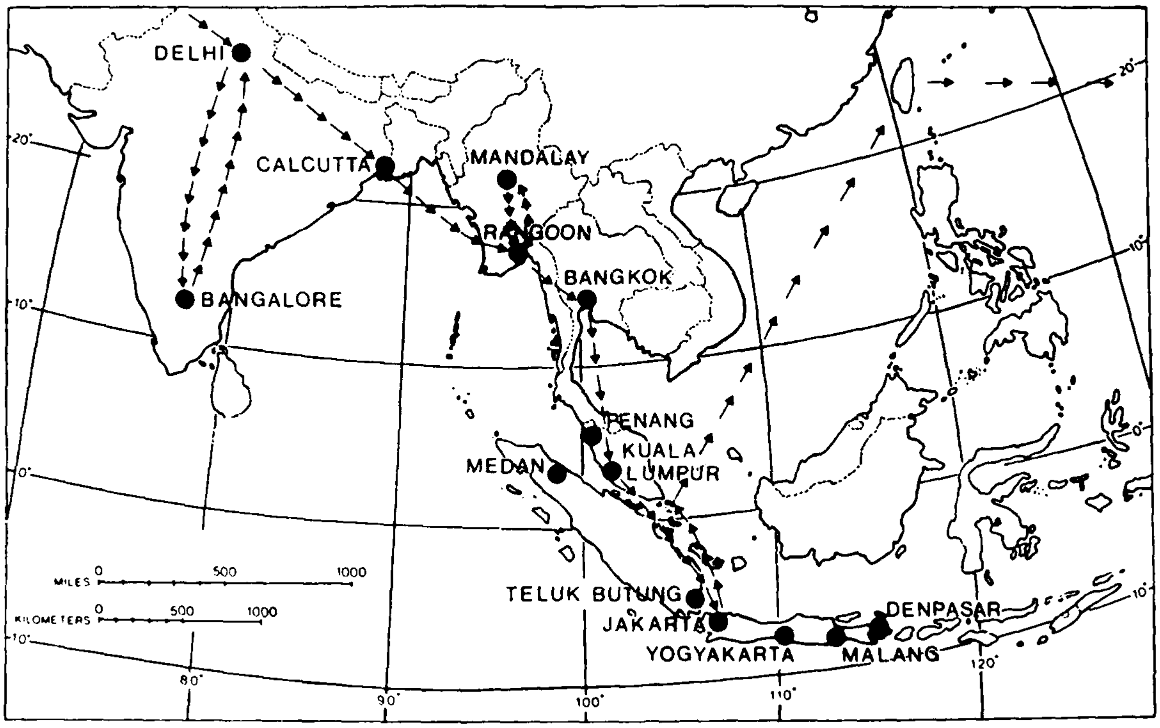



Figure 2. Route of first (1981) trip surveying for hydrilla insects. Primary focus on this trip was collecting on the Indonesian islands of Java and Sumatra

Figure 3 shows the route of this 1982 trip. Appendix E presents a brief log of the activities during this trip. The final trip in 1983 was directed primarily to collecting in areas not visited during the previous trips. The primary areas of focus for this 1983 trip were the Philippine islands of Luzon, Mindanao, and Cebu, along with Sabah (North Borneo), Papua New Guinea, and Kashmir India. The route of this trip is shown in Figure 4 and

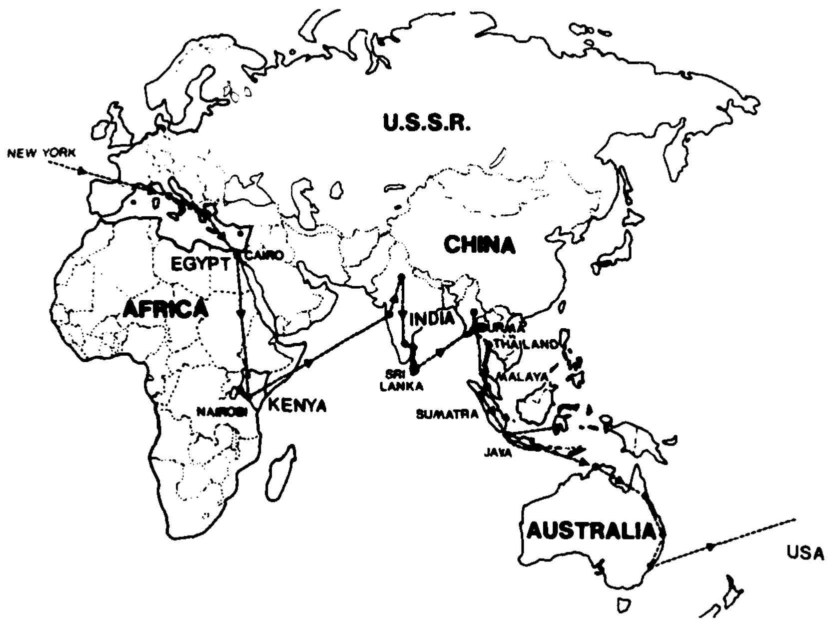



Figure 3. Route of second (1982) trip surveying for hydrilla insects. Primary goals for this trip were: testing weevils in India; revisiting sites in Southeast Asia surveyed on previous trip; and surveying in new areas, especially Sri Lanka, Sulawesi, and Australia

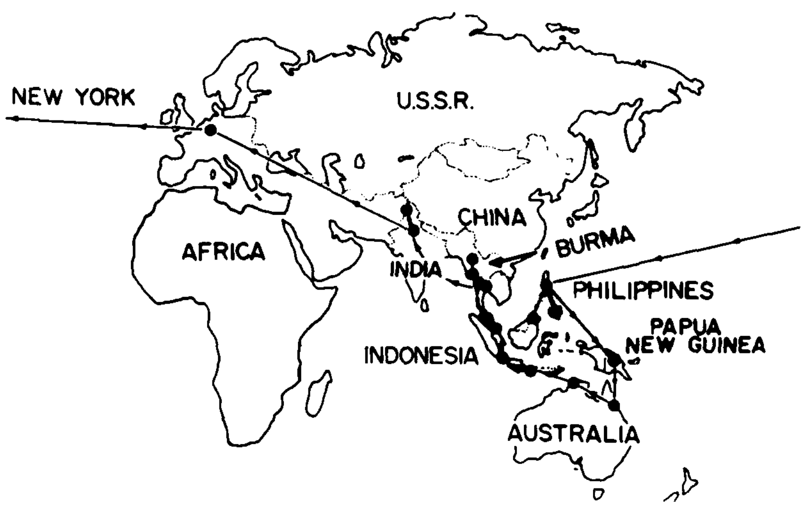



Figure 4. Route of third (1983) trip surveying for hydrilla insects. The aim of this trip was to survey in areas not visited on the previous trips. This included the Philippines, Borneo, and Papua New Guinea

Appendix F presents the log of this trip.

57. After each trip, a complete report was prepared and circulated to the funding agencies, cooperators, and other interested scientists. While copies of each trip report can be obtained from the author, an abbreviated version of each report can be found in Balciunas (1982, 1983, and 1984). This final report is meant to serve as a compilation and summary, rather than presenting again all the information found in the previous documents.

58. Appendix G lists all sites at which hydrilla insects were collected by hand searches or berlese funnels during these three trips. Appendix H lists the water quality data and other environmental parameters at these sites. The UV light collection sites are listed in Appendix I. Appendix J lists the sites where insects from plants other than hydrilla were collected.

59. Table 1 is a compilation of all the insects and other macrofauna collected during these three trips. Appendix K presents the faunal numbers and the corresponding biomass of the plant material searched.

Table 1

Preliminary List of Insects and Other Invertebrates Collected from Hydrilla (Rake and Berlese Samples) in Asia and Australia

| Name | Country | Specimens | Collections |
|---|---|---|---|
| | | Insects | |
| Order Coleoptera (Beetles) | | | |
| Curculionidae | Australia | 1 | NTR832Z2 |
| *Bagous* spp. | India | 44 | KAR81203, KAR81205, KAR81206, KAR82205, KAR82206, KAR82207, KAS832Z1 |
| Dryopidae | Indonesia | 3 | SUM81205 |
| | Malaysia | 1 | PRK83201 |
| Dytiscidae | Australia | 3 | QLD82202, QLD82203, QLD832Z2 |
| | Burma | 1 | BUR83203 |
| | India | 4 | KAR82202 |
| | Indonesia | 1 | JAV81201 |
| | Malaysia | 2 | PEN82203, PRK83201 |
| | New Guinea | 1 | PAP832Z5 |
| | Philippines | 1 | LUZ832Z2 |
| Elmidae | Australia | 3 | QLD832Z2 |
| | Malaysia | 79 | PRK83201 |
| Helodidae | Malaysia | 2 | PRK83203 |
| Hydrophilidae | | | |
| *Hydrochus* spp. | Malaysia | 4 | PEN82202 |
| | Philippines | 1 | MDN83201 |
| Undetermined spp. | Australia | 3 | NTR832Z2, QLD82202, QLD82203, |
| | India | 36 | KAR81202, KAR81206, KAR82201, KAR82203, KAR82204, KAR82205, KAR82206, KAR82207 |
| | Indonesia | 1 | BAL83201 |
| | Malaysia | 2 | PEN82202, PRK83202 |
| | Philippines | 2 | LUZ83202, LUZ832Z2 |
| Noteridae | Burma | 1 | BUR82206 |
| Undetermined Coleoptera | Philippines | 4 | LUZ83202, LUZ832Z2, MDN832Z2 |
| | Total | 200 | |

(Continued)

(Sheet 1 of 12)

Table 1 (Continued)

| Name | Country | Specimens | Collections |
|---|---|---|---|
| Order Diptera (True Flies) | | | |
| Ceratopogonidae | Australia | 1 | QLD832Z2 |
| | Burma | 2 | BUR82202 |
| | India | 1 | KAR82202 |
| | Indonesia | 2 | LOM82201 |
| | Malaysia | 5 | PEN82203, PFN82204, PFN832Z1, PRK83203 |
| | New Guinea | 15 | PAP83205, PAP832Z5, PAP832Z6 |
| | Philippines | 91 | MDN832Z1, MDN832Z2, MDN832Z3 |
| Chironomidae | Australia | 78 | NTR82201, NTR82202, NTR83201 NTR832Z1, NTR832Z2, QLD82202 QLD82203, QLD83202, |
| | Burma | 10 | BUR82202, BUR82203, BUR82204, BUR83201, BUR83203 |
| | India | 19 | KAR81203, KAR82201, KAR82202, KAR82205, KAR82206, KAS83202 |
| | Indonesia | 232 | JAV81204, JAV81205, LOM82201 SUL82201, SUL82202, SUM81201 |
| | Malaysia | 385 | PEN82201, PEN82202, PEN82203, PEN82204, PEN832Z5, PRK82202, PRK82206, PRK82207, PRK82208, PRK82210, PRK82211, PRK82212, PRK83201, PRK83202, PRK83203, |
| | New Guinea | 144 | PAP83205, PAP83206, PAP832Z5, PAP832Z6 |
| | Philippines | 32 | LUZ83201, LUZ832Z1, LUZ832Z2, MDN83201, MDN83202, MDN832Z1, MDN832Z2 |
| | Sri Lanka | 3 | LAN82201, LAN82202, LAN82204 |
| Culicidae | Indonesia | 1 | BAL832Z1 |
| | Malaysia | 23 | PEN82202, PRK82210, PRK82211, PRK82212 |
| Dolichopodidae | Australia | 2 | QLD83202 |
| Ephydridae | | | |
| *Hydrellia* spp. | Australia | 82 | NTR83201, NTR83202, NTR832Z1, NTR832Z2 |

(Continued)

(Sheet 2 of 12)

Table 1 (Continued)

| Name | Country | Specimens | Collections |
|---|---|---|---|
| Undetermined spp. | India | 16 | KAR82205, KAR82207, KAS832Z1 |
| | Malaysia | 7 | PRK83201, PRK83202, |
| | New Guinea | 1 | PAP83205 |
| | Philippines | 1 | MDN832Z2 |
| Psychodidae | Australia | 4 | NTR832Z2 |
| | Malaysia | 3 | PRK83202 |
| Simulidae | Philippines | 1 | LUZ832Z2 |
| Stratiomyidae | India | 1 | KAR82206 |
| | Indonesia | 2 | JAV81204, SUL82201 |
| Undetermined | Australia | 6 | NTR832Z1, QLD832Z2 |
| | Total | 1170 | |
| Order Ephemeroptera (Mayflies) | | | |
| Baetidae | Australia | 3 | NTR83201, NTR832Z2 |
| | Burma | 1 | BUR82205 |
| | India | 2 | KAR81206, KAR82201 |
| | Indonesia | 2 | JAV81203 |
| | Malaysia | 12 | PEN82203, PRK82206, PRK82211, PRK82212, PRK83201 |
| | Sri Lanka | 3 | LAN82201, LAN82202, LAN82203 |
| Caenidae | Australia | 2 | QLD82202, NTR83202 |
| | Malaysia | 3 | PEN81202, PRK82201, PRK83201 |
| | Sri Lanka | 2 | LAN82204 |
| Leptophlebiidae | Australia | 3 | QLD82202 |
| | Total | 33 | |
| Order Hemiptera (True Bugs) | | | |
| Belostomatidae | Australia | 7 | NTR83201, NTR832Z1 |
| | Burma | 4 | BUR82202 |
| | India | 10 | KAR82201, KAR82203, KAR82204 |
| | Indonesia | 2 | SUL82202 |
| | Malaysia | 3 | PEN82203 |
| | New Guinea | 2 | PAP83205 |
| | Sri Lanka | 1 | LAN82202 |
| | Thailand | 2 | PHK82201 |
| Corixidae | Australia | 10 | NTR83201, NTR83202, NTR832Z1, NTR832Z2 |

(Continued)

(Sheet 3 of 12)

Table 1 (Continued)

| Name | Country | Specimens | Collections |
|---|---|---|---|
| Corixidae (Cont'd) | Burma | 8 | BUR82205, BUR83201, BUR83203, BUR832Z1, BUR832Z2, BUR832Z3 |
| | Malaysia | 53 | PEN82205, PEN83201, PRK82209, PRK82210, PRK82211, PRK82212, PRK83202 |
| Gerridae | India | 6 | KAR82201, KAR82204, KAR82206 |
| | Malaysia | 1 | PRK83203 |
| | New Guinea | 2 | PAP832Z5 |
| Mesoveliidae | India | 11 | KAR82203, KAR82204, KAR82205 |
| | New Guinea | 4 | PAP83205, PAP832Z4 |
| Naucoridae | Burma | 2 | BUR83201 |
| *Pelocoris* spp. | India | 1 | KAR82202 |
| | Sri Lanka | 2 | LAN82203 |
| Nepidae | | | |
| (*Laccotrephes* spp.?) | India | 1 | KAR82201 |
| | Indonesia | 1 | SUM81204 |
| *Ranatra* spp. | Australia | 1 | NTR82202 |
| | Burma | 1 | BURB2205 |
| | India | 1 | KAR82201 |
| | Indonesia | 2 | JAV81204 |
| | Malaysia | 2 | PEN82203, PEN82205 |
| | Sri Lanka | 1 | LAN82204 |
| Notonectidae | Australia | 1 | NTR832Z1 |
| Pleidae | Australia | 35 | NTR83201, NTR83202, NTR832Z1, NTR832Z2 |
| | Burma | 27 | BUR82202, BUR82204, BUR82205, BUR83201, BUR83202, BUR832Z1, BUR832Z2 |
| | India | 47 | KAR82201, KAR82202, BUR82203, KAR82206, KAR82207 |
| | Malaysia | 16 | PEN82203, PEN832Z1, PRK82201, PRK82202, PRK83203 |
| | New Guinea | 4 | PAP83205, PAP832Z4 |
| | Sri Lanka | 2 | LAN82204 |
| | Thailand | 1 | PHK82201 |

(Continued)

(Sheet 4 of 12)

Table 1 (Continued)

| Name | Country | Specimens | Collections |
|---|---|---|---|
| Veliidae | Astralia | 9 | NTR83201, QLD83202 |
| (Cont'd) | Malaysia | 3 | PEN832Z1, PRK83202 |
| | Total | 286 | |
| Order Homoptera (Aphids) | | | |
| Aphididae | Malaysia | 7 | PEN82202, PRK83201 |
| | Total | 7 | |
| Order Hymenoptera (Bees and Wasps) | | | |
| Braconidae | | | |
| *Ademon* sp. | India | 1 | KAR82202 |
| *Chaenusa* sp. | India | 2 | KAR82202, KAR82207 |
| Undetermined sp. | Australia | 2 | NTR83201, NTR83202 |
| Undetermined Hymenoptera | Australia | 3 | NTR832Z1, NTR832Z2 |
| | New Guinea | 7 | PNG832Z3 |
| | Philippines | 1 | LUZ832Z2 |
| | Total | 16 | |
| Order Lepidoptera (Butterflies and Moths) | | | |
| Pyralidae | | | |
| *Parapoynx diminutalis* | Burma | 14 | BUR82201, BUR82204, BUR82205, BUR83202 |
| | India | 63 | KAR81201, KAR81201, KAR81203, KAR81204, KAR81205, KAR82201, KAR82202, KAR82204, KAR82205, KAR82207 |
| | Indonesia | 43 | JAV81201, JAV81203, JAV81204, JAV81205, JAV81206, SUL82201, SUL82202, SUM81201, SUM81204, SUM81205 |
| | Malaysia | 201 | PEN832Z1, PRK82202, PRK83201, PRK83203 |
| | Sri Lanka | 85 | LAN82203, LAN82204 |
| | Thailand | 22 | PHK82202 |

(Continued)

(Sheet 5 of 12)

Table 1 (Continued)

| Name | Country | Specimens | Collections |
|---|---|---|---|
| *Parapoynx* prob. *dicentra* | Australia | 99 | NTR82201, NTR82202, NTR82203, NTR83201, NTR83202, NTR832Z1, NTR832Z2, QLD83201 |
| *Parapoynx* spp. | Australia | 4 | QLD82203, QLD832Z1 |
| | India | 2 | KAS832Z1, KAS832Z3 |
| | Indonesia | 2 | LOM82201 |
| | Malaysia | 3 | PRK83201 |
| | New Guinea | 4 | PAP83206, PAP832Z6 |
| | Pilippines | 1 | LUZ832Z1 |
| *Nymphula* spp. | India | 2 | KAR81201, KAR82202 |
| Undetermined spp. | Australia | 15 | QLD82202, QLD83202, QLD832Z1 |
| | Burma | 1 | BUR82205 |
| | India | 1 | KAR81201 |
| | Indonesia | 1 | BAL832Z1 |
| | New Guinea | 3 | PAP832Z1, PAP832Z2, PAP832Z3 |
| | Philippines | 6 | LUZ832Z1, LUZ832Z2, MDN83202, MDN832Z3 |
| | Sri Lanka | 1 | LAN82203 |
| | Total | 573 | |
| Order Odonata<br>Suborder Anisoptera (Dragonflies) | | | |
| Aeschnidae | Burma | 2 | BUR82205 |
| | New Guinea | 4 | PAP83205 |
| Gomphidae | India | 1 | KAR82202 |
| | Indonesia | 4 | JAV81201, SUM81205 |
| | Malaysia | 2 | PEN82201 |
| Libellulidae | Australia | 3 | NTR83202, QLD82204, QLD832Z1 |
| | India | 3 | KAR81202, KAR81206, KAR82206 |
| | Indonesia | 5 | JAV81201, JAV81202, JAV81204, SUM81204 |
| | Malaysia | 2 | PEN81201, PEN82203 |
| | New Guinea | 2 | PAP83205 |
| | Sri Lanka | 3 | LAN82201, LAN82203, LAN82205 |
| | Thailand | 1 | PHK82201 |
| Suborder Zygoptera (Damselflies) | | | |
| Coenagrionidae | Australia | 29 | NTR83201, NTR83202, NTR832Z1, NTR832Z2, QLD82202, QLD83202 |

(Continued) (Sheet 6 of 12)

Table 1 (Continued)

| Name | Country | Specimens | Collections |
|---|---|---|---|
| Coenagrionidae (Cont'd) | Burma | 31 | BUR82204, BUR82205, BUR83201, BUR832Z1, BUR832Z2 |
| | India | 8 | KAR82202, KAR82203, KAR82207, KAS832Z1 |
| | Indonesia | 34 | JAV81201, JAV81203, JAV81204, JAV81205, SUL82201, SUM81204 |
| | Malaysia | 37 | PEN82203, PEN83201, PEN832Z1, PRK82206, PRK82207, PRK82208, PRK82209, PRK82210, PRK82211, PRK82212, PRK83201 |
| | New Guinea | 10 | PAP83203, PAP83205, PAP832Z1, PAP832Z3, PAP832Z5 |
| | Philippines | 2 | LUZ832Z1 |
| | Sri Lanka | 17 | LAN82201, LAN82202, LAN82203, LAN82204 |
| | Thailand | 2 | PHK82201 |
| | Total | 202 | |
| Order Orthoptera (Grasshoppers and Crickets) | | | |
| Tridactylidae | India | 1 | KAR81205 |
| | Total | 1 | |
| Order Trichoptera (Caddisflies) | | | |
| Hydropsychidae | Malaysia | 45 | PRK83201 |
| Hydroptilidae | | | |
| (*Orthotrichia* spp.?) | Australia | 1 | NTR82201 |
| | Burma | 4 | BUR82203 |
| | Indonesia | 1 | LON82201 |
| | New Guinea | 3 | PAP83206 |
| (*Oxyethira* sp.?) | Australia | 1 | NTR82201 |
| Undetermined spp. | Malyasia | 3 | PRK82208, PRK83202 |
| Leptoceridae | | | |
| *Leptocerus* spp. | Australia | 2 | NTR82201 |
| | Burma | 4 | BUR82203, BUR83201 |
| | Indonesia | 9 | SUL82201 |
| | New Guinea | 2 | PAP83206 |

(Continued)

(Sheet 7 of 12)

Table 1 (Continued)

| Name | Country | Specimens | Collections |
|---|---|---|---|
| (*Oecetis* spp.?) | Australia | 5 | NTR83202, NTR832Z2 |
| | Indonesia | 3 | SUM81203 |
| | New Guinea | 9 | PAP83205, PAP83206 |
| Undetermined spp. | Australia | 2 | NTR82201, QLD82202 |
| | India | 1 | KAR82202 |
| | Sri Lanka | 2 | LAN82202 |
| Polycentropodidae | Australia | 5 | NTR82202, QLD82203 |
| | Indonesia | 20 | JAV81201 |
| | Malaysia | 3 | PRK82209, PRK82211 |
| Undetermined Trichoptera | Australia | 8 | NTR82202, NTR82203, QLD82202 |
| | India | 2 | KAR81202, KAR82206 |
| | Total | 135 | |
| **Other Invertebrates** | | | |
| Class Arachnida Subclass Acari | | | |
| Aquatic Mites | Australia | 7 | NTR832Z2, QLD83202, QLD832Z2 |
| | Burma | 1 | BUR83202 |
| | India | 3 | KAR82205, KAR82206 |
| | Malaysia | 3 | PEN832Z1, PRK82203, PRK82208 |
| | New Guinea | 50 | PAP832Z2 |
| | Total | 64 | |
| Class Crustaceae Order Amphipoda | | | |
| Scuds | Australia | 1 | QLD82201 |
| | Philippines | 1 | LUZ832Z2 |
| Order Cladocera | | | |
| Water Fleas | Malaysia | 6 | PEN82203, PEN82204, PRK82210 |
| | Sri Lanka | 3 | LAN82204 |
| Order Decapoda | | | |
| Shrimp (*Macrobrachium* sp.) | Indonesia | 1 | SUM81201 |

(Continued)

(Sheet 8 of 12)

Table 1 (Continued)

| Name | Country | Specimens | Collections |
|---|---|---|---|
| (*Palaemon* sp.) | Australia | 25 | NTR83201, NTR83202, QLD82201, QLD82204, QLD83202 |
| | Burma | 23 | BUR82204, BUR82205, BUR82206, BUR83201 |
| | India | 3 | KAR81203, KAR82202 |
| | Indonesia | 16 | JAV81202, JAV81203, SUM81201, SUM81204 |
| | Philippines | 5 | LUZ83202, LUZ832Z2 |
| | Sri Lanka | 4 | LAN82204 |
| Crabs | Australia | 2 | QLD82201 |
| Order Isopoda | | | |
| Aquatic Isopods | Indonesia | 1 | JAV81202 |
| Order Ostracoda | | | |
| Seed Shrimp | Burma | 4 | BUR83201, BUR83203, BUR82Z3 |
| | Indonesia | 1 | SUL82201 |
| | Malaysia | 4 | PEN82203, PEN832Z1, PRK82211 |
| Order Tanaidacea | | | |
| Tanaids | Philippines | 5 | LUZ32Z1, LUZ832Z2 |
| | Total | 105 | |
| Class Mollusca<br>Order Gastropoda (Snails) | | | |
| Ampullariidae | Burma | 3 | BUR82204 |
| | Malaysia | 1 | PRK82205 |
| Hydrobiidae | Burma | 41 | BUR82203, BUR82204, BUR82205, BUR82206, BUR83201, BUR832Z1, BUR832Z2 |
| | India | 55 | KAR81201, KAR81204, KAR81205, KAR81206, KAR82201, KAR82202, KAR82203, KAR82205, KAR82206 |
| | Indonesia | 4 | JAV81203 |
| | New Guinea | 14 | PAP83203, PAP83206 |
| | Sri Lanka | 155 | LAN82202, LAN82203, LAN82204 |
| Lymnaeidae | Burma | 22 | BUR82201, BUR82202, BUR82204, BUR83202, BUR832Z2 |

(Continued)

(Sheet 9 of 12)

Table 1 (Continued)

| Name | Country | Specimens | Collections |
|---|---|---|---|
| Lymnaeidae (Cont'd) | India | 37 | KAR81203, KAR82201, KAR82203, KAR82205, KAR82206, KAS832Z1, KAS832Z3, KAS832Z4 |
| | Indonesia | 30 | JAV81201, JAV81203, JAV81205, SUL82202, SUM81204 |
| | Sri Lanka | 18 | LAN82202 |
| | Thailand | 17 | PHK82201 |
| Physidae | Australia | 27 | NTR82201, NTR82203, NTR83201, NTR83202, NTR832Z1, NTR832Z2, QLD82203 |
| | Burma | 7 | BUR82206, BUR83202, BUR832Z2, BUR832Z3 |
| | India | 18 | KAR81201, KAR81205, KAR82201, KAR82203, KAR82206 |
| | Indonesia | 39 | BAL83201, BAL832Z1, JAV81201, SUM81205 |
| | Malaysia | 30 | PEN82201, PEN82203, PEN82204, PEN83201, PEN832Z1, PRK82201 |
| | New Guinea | 21 | PAP83203, PAP83205, PAP83206, PAP832Z3, PAP832Z4 |
| | Philippines | 1 | MDN83201 |
| | Sri Lanka | 47 | LAN82201, LAN82202, LAN82203, LAN82204 |
| | Thailand | 31 | PHK82201 |
| Planorbidae (*Gyraulus* spp.?) | Australia | 3 | NTR83201, NTR832Z1 |
| | Burma | 442 | BUR81201, BUR81202, BUR82203, BUR82204, BUR82205, BUR82206, BUR83201, BUR83202, BUR83203, BUR832Z1, BUR832Z2, BUR832Z3 |
| | India | 36 | KAR81201, KAR81202, KAR81205, KAR82201, KAR82206 |
| | Indonesia | 131 | JAV81204, JAV81206, SUL82201, SUL82202, SUM81204 |
| | Malaysia | 35 | PEN832Z1, PRK82201, PRK82202, PRK82204, PRK82209, PRK82210 PRK82211 |
| | New Guinea | 40 | PAP83203, PAP832Z3 |
| | Philippines | 3 | LUZ83202 |
| | Sri Lanka | 28 | LAN82201, LAN82204, LAN82205 |
| | Thailand | 9 | PHK82201 |

(Continued)

(Sheet 10 of 12)

Table 1 (Continued)

| Name | Country | Specimens | Collections |
|---|---|---|---|
| *Helisoma* spp. | Burma | 4 | BUR82202, BUR83202, BUR832Z2 |
| | India | 16 | KAR81201, KAR81205, KAR82201, KAR82205 |
| | Indonesia | 10 | BAL83201, BAL832Z1, JAV81201 |
| | Malaysia | 15 | PEN83201, PEN832Z1, PRK82201, PRK82204, PRK82205 |
| | Sri Lanka | 20 | LAN82202, LAN82204, LAN82205 |
| | Thailand | 103 | PHK82201 |
| Pleuroceridae | Australia | 5 | NTR82201, QLD82201 |
| | Burma | 14 | BUR82201, BUR82206, BUR83202, BUR83203 |
| | India | 4 | KAR81201, KAR81203, KAR82201 |
| | Indonesia | 39 | BAL83201, LOM82201, SUL82202, SUM81201, SUM81202, SUM81203, SUM81204, SUM81205 |
| | Malaysia | 34 | PEN83201, PEN832Z1, PRK82201, PRK82205 |
| | New Guinea | 40 | PAP83203, PAP832Z2, PAP832Z3 |
| | Philippines | 35 | LUZ83201, LUZ83202, LUZ832Z1, LUZ832Z2 |
| | Sri Lanka | 2 | LAN82205 |
| | Thailand | 2 | PHK82201 |
| Viviparidae | Australia | 1 | NTR83201 |
| | Burma | 9 | BUR81201, BUR82204, BUR82206, BUR832Z2 |
| | India | 4 | KAR82201 |
| | Indonesia | 33 | BAL83201, BAL832Z1, JAV81201, SUM81204 |
| | Malaysia | 6 | PEN83201, PRK82201, PRK82210 |
| | Sri Lanka | 5 | LAN82201, LAN82202 |
| | Thailand | 2 | PHK82201 |
| | Total | 1748 | |
| <u>Order Pelecypoda (Clams)</u> | | | |
| Corbiculidae | Indonesia | 9 | SUM81201, SUM81202 |
| Sphaeriidae | Indonesia | 1 | SUM81205 |
| | Total | 10 | |

(Continued)

Table 1 (Concluded)

| Name | Country | Specimens | Collections |
|---|---|---|---|
| Class Oligochaeta | | | |
| Oligochaete Worms | Australia | 2 | NTR83201 |
| | India | 1 | KAR82206 |
| | Malaysia | 18 | PEN82203, PRK82204, PRK83201 |
| | New Guinea | 22 | PAP832Z2 |
| | Philippines | 1 | LUZ83201 |
| Leeches | India | 2 | KAR82203 |
| | Indonesia | 1 | LOM82201 |
| | Malaysia | 4 | PEN82201, PRK82201 |
| | Sri Lanka | 6 | LAN82201, LAN82202, LAN82204 |
| | Total | 57 | LAN82205 |

(Sheet 12 of 12)

## PART IV: DISCUSSION

### General

60. These surveys consisted of three extended trips during which approximately 15 months were spent abroad searching for hydrilla and its natural enemies. Most of these surveys were conducted in the tropics of Asia and Australia. However, Dal Lake in Kashmir India, at a latitude of 34°N and with its high elevation of 1,770 m, was temperate and climatically similar to Denver, Colo. (Gale Research 1983).

61. The foreign exploration phase of most biological control programs usually involves the establishment of permanent laboratories, and staffing by several scientists and supporting personnel. However, funding for the exploration phase of this hydrilla project was only sufficient for a single, home-based scientist. Also, unlike previous biocontrol efforts, the area of endemism for hydrilla could not be pinpointed. All funds not obligated for salaries and overhead were directed for travel and related survey expenses. Using an around-the-world airline ticket, this allowed for 3 to 5 months abroad, depending on the areas visited. Because of lower costs of conducting research, less-developed countries in Asia were favored. Additional funds provided by USDA's Far Eastern Regional Research Organization allowed for an extra month in India on both the second and third trips.

62. The strategy chosen for these surveys was to collect hydrilla-damaging insects at as many sites in Asia and Australia as funding would permit. While this approach of spending a short time at many different locations precluded any in-depth studies of a particular species, it increased the probability that many hydrilla-damaging insects would be discovered.

63. During the three survey trips, 89 collections of hydrilla were hand searched for natural enemies. This was supplemented by the insects processed from hydrilla in 26 berlese funnel collections. The 26 UV light collections were very helpful in providing adult stages of the insects damaging hydrilla. Field host specificity data were gained from 36 collections of insects on aquatic plants other than hydrilla. These 187 collections provided information for preliminary decisions about the potential for the biological control of hydrilla.

## Distribution of Hydrilla

64. At the beginning of this study the author had only a vague idea of the distribution of hydrilla in Asia. Knowledge of hydrilla sites in Australia was more precise but because hydrilla is usually not a pest there, hydrilla's actual distribution was thought to be more extensive in Australia than indicated by the herbarium records.

65. Dr. C. D. K. Cook provided a list of hydrilla herbarium records which he had verified. These herbaria records are plotted as closed circles on the maps in Figures 5-8. The areas where hydrilla was collected during the present surveys are shown as open circles. Figure 5 depicts the records in South Asia and Southeast Asia. Many botanists have visited India, and the distribution of hydrilla is better known there than any other Asian country. Hydrilla is much more widespread in Sri Lanka, the island nation off the southern tip of India, than the single herbarium record from there would indicate. A similar situation exists in Burma. Likewise, hydrilla would probably be considered to be more widely distributed throughout Thailand and Indo-China with more collecting in those area. There are many records of hydrilla from the small nation of Nepal. The original specimen from which this species was described probably came from that portion of the Himalayas. The author did not collect in Nepal, primarily because of the lack of a contact there to provide advice and information.

66. Figure 6 shows the relatively few records of hydrilla from China and the Far East. This almost certainly reflects the lack of collecting by aquatic botanists and hydrilla is probably common there.

67. Figure 7 depicts the hydrilla collections in Malaysia, Indonesia, the Philippines, and Papua New Guinea. Hydrilla is widespread throughout this region, but seldom forms dense stands. It is relatively rare on the island of Borneo, at least in the northern part (Sabah) where the author spent 2 weeks unsuccessfully searching.

68. Figure 8 illustrates the known hydrilla collection sites in Australia. Most of these collections are concentrated in the southeast portion near Sydney and Melbourne, near major Australian Universities. The author's collecting was confined to the Darwin and Cairns vicinities in the north, where hydrilla was available during winter and early spring when the author visited Australia.

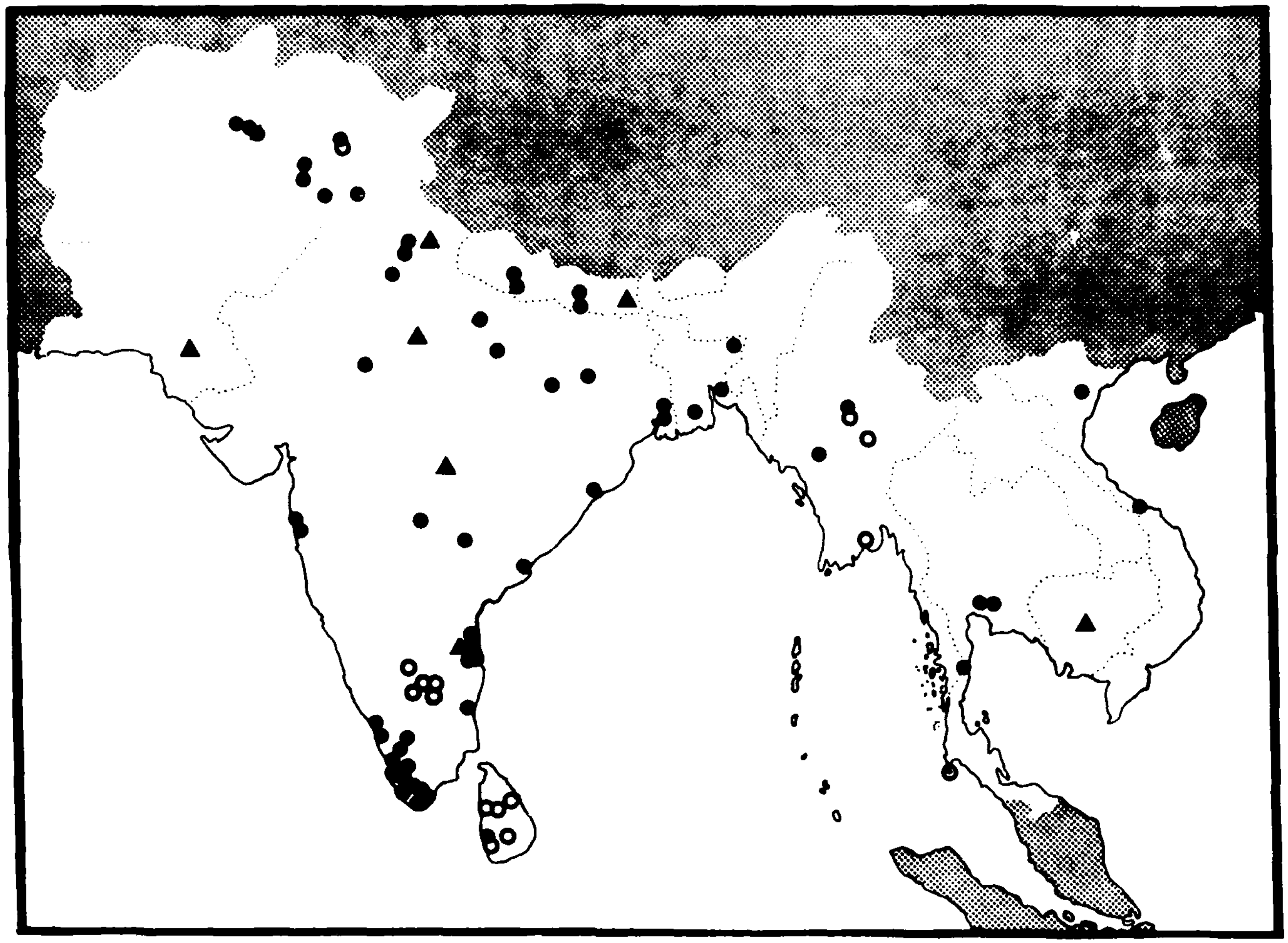


Figure 5. Location of sites where hydrilla herbarium specimens have been collected in South and Southeast Asia. Closed circles represent hydrilla specimens assembled from various herbaria by Dr. C. D. K. Cook. The open circles are additional sites where hydrilla was collected by J. K. Balciunas. Triangles represent other reported hydrilla sites. Hydrilla records are not plotted for shaded portions of this map

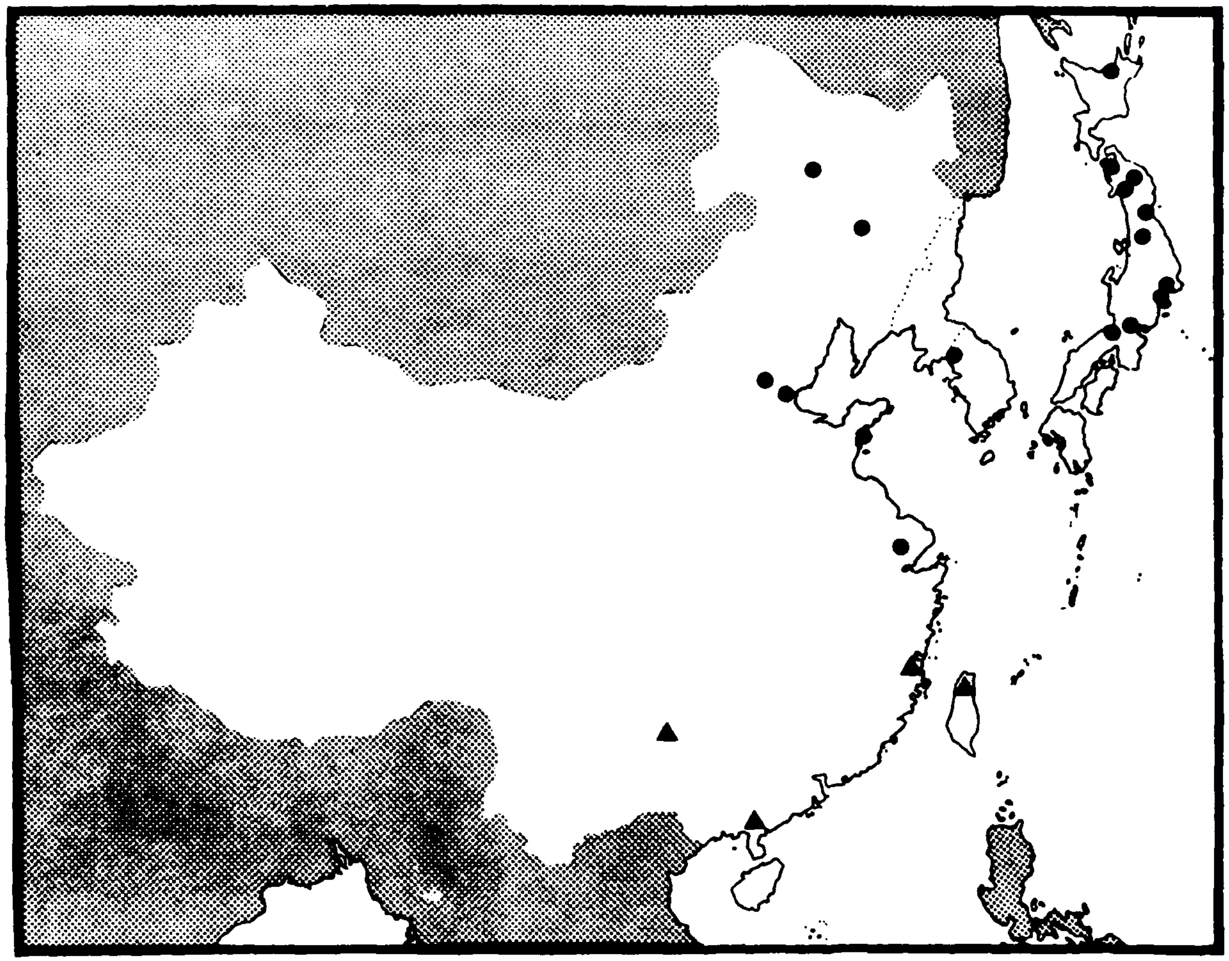


Figure 6. Location of sites where hydrilla herbarium specimens have been collected in China, Korea, and Japan. Closed circles represent hydrilla specimens assembled from various herbaria by Dr. C. D. K. Cook. Triangles represent other reported hydrilla sites. Hydrilla records are not plotted for shaded portions of this map

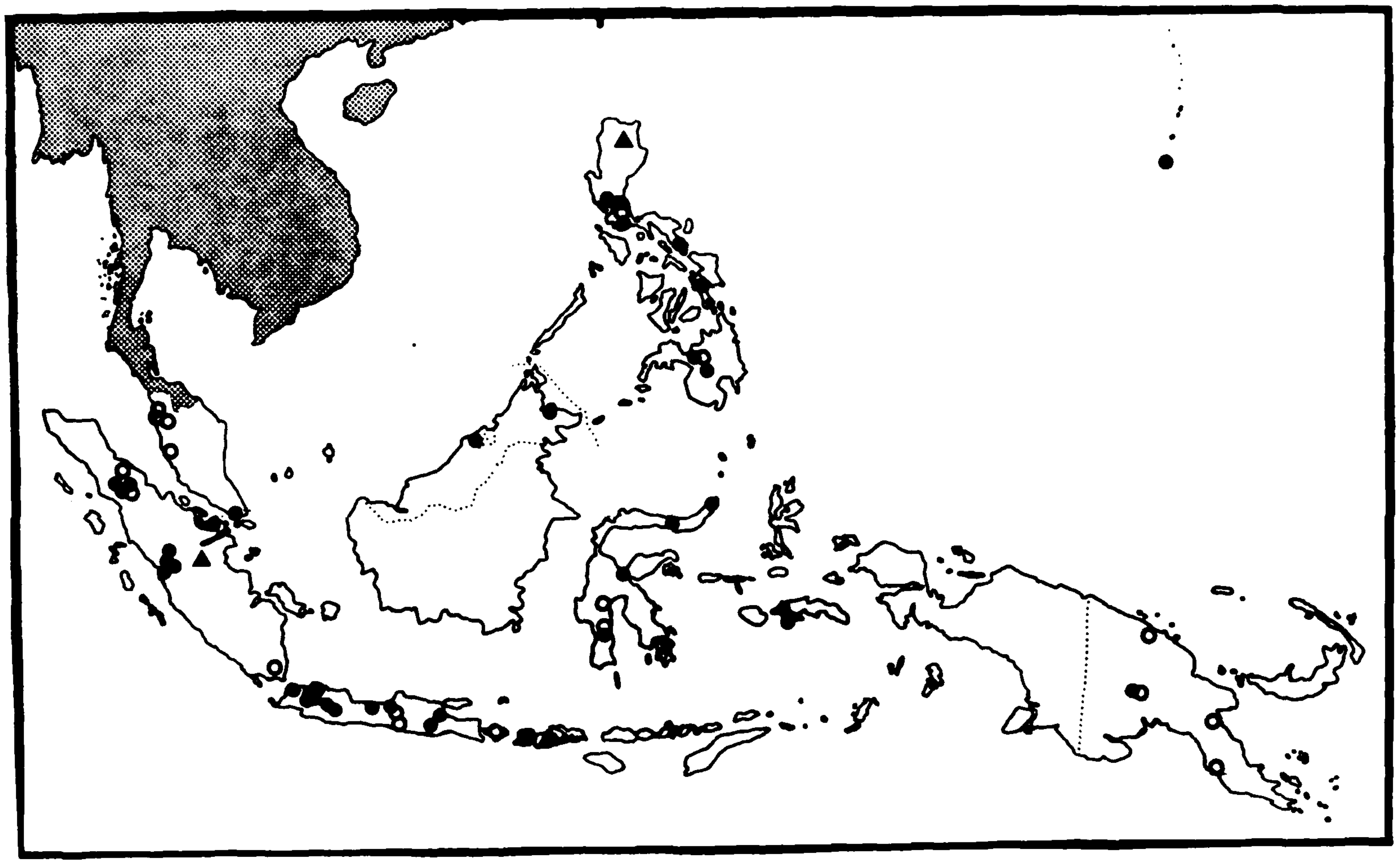


Figure 7. Location of sites where hydrilla herbarium specimens have been collected in Malaysia, Indonesia, the Philippines, and Papua New Guinea. Closed circles represent hydrilla specimens assembled from various herbaria by Dr. C. D. K. Cook. The open circles are additional sites where hydrilla was collected by J. K. Balciunas. Triangles represent other reported hydrilla sites. Hydrilla records are not plotted for shaded portions of this map

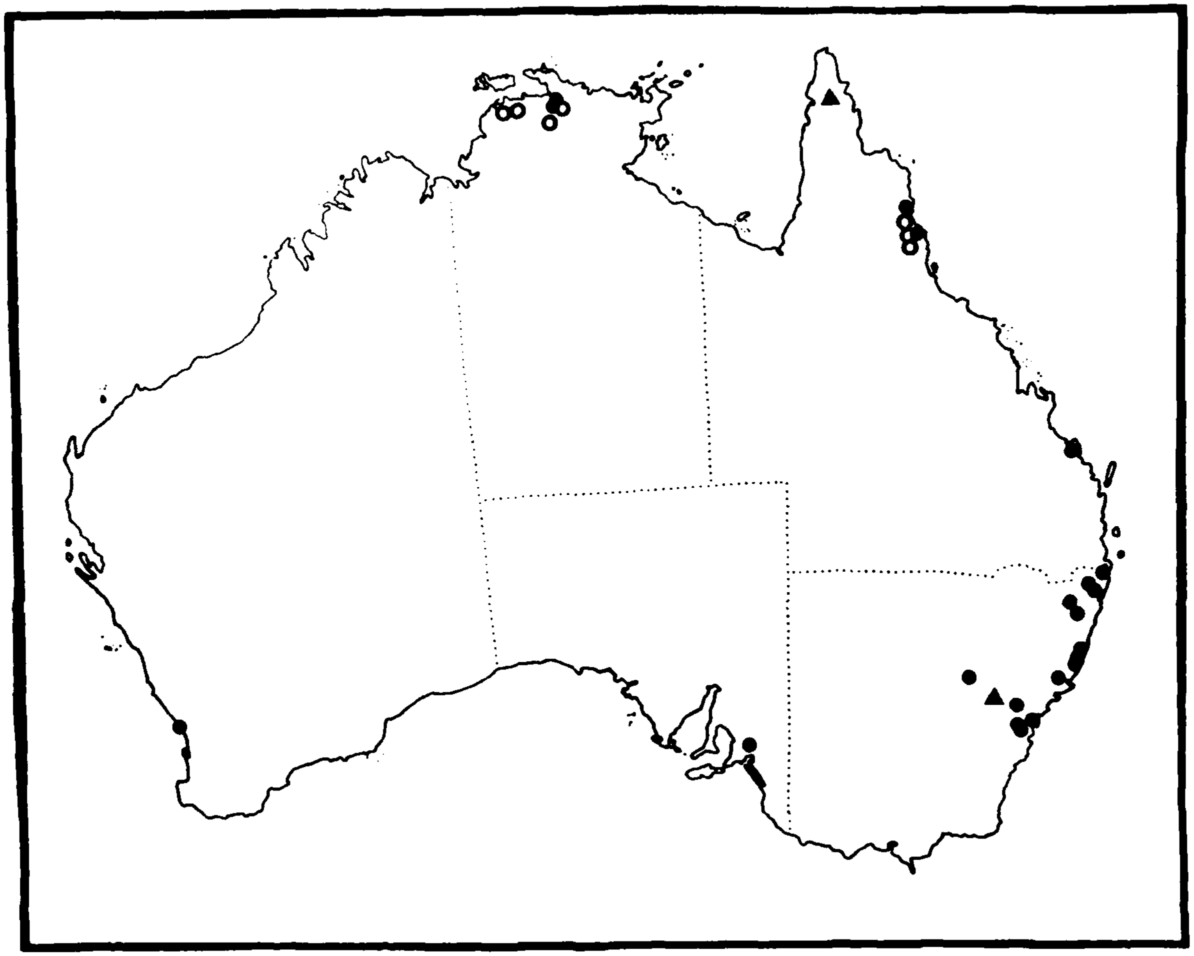


Figure 8. Location of sites where hydrilla herbarium specimens have been collected in Australia. Closed circles represent hydrilla specimens assembled from various herbaria by Dr. C. D. K. Cook. The open circles are additional sites where hydrilla was collected by J. K. Balciunas. Triangles represent other reported hydrilla sites

## Hydrilla's Pest Status Overseas

69. While hydrilla is widespread in many areas of Asia and Australia, to say that it is common may mislead persons familiar with hydrilla infestations only in the United States. The dense monocultures of hydrilla, typical of those in Florida and Texas, are very rarely encountered in Asia and Australia. There, hydrilla is usually found in small clumps of one to three plants (Figure 9) or, at sites where it is more abundant, hydrilla forms a band near the shoreline.

Figure 9. Arrows point to hydrilla growing in a Sri Lanka stream. This is typical of hydrilla growth in Asia where hydrilla very rarely forms dense monocultures

70. This type of growth habit requires diligent searching to locate hydrilla. A local botanist might consider hydrilla "common" since it was present at 20 percent of the likely habitats. However, the author often spent several days surveying in the same area before finally locating hydrilla. If the visit occurred early in the growing season and hydrilla had not yet "topped-out" and become visible at the surface, then locating it was much more difficult. During periods of high water, such as after the monsoon rains, sites would be covered by an additional several metres of muddy water and hydrilla would be impossible to locate.

## Possible Hydrilla Pathogen

71. At Lake Toba on the Indonesian island of Sumatra, hydrilla was widespread but fairly difficult to locate because it invariably occurred as a low-growing, prostrate clump, deep beneath the surface, even though the pondweeds (*Potomageton* spp.) and milfoil (*Myriophyllum spicatum*), growing beside it were "topped-out" and normal in appearance (Figure 10). Examination of the hydrilla shoots showed that almost all apical tips were missing. Pemberton (1980) observed similar damage to hydrilla in Africa at Lake Tanganyika and surmised that the apical meristems had been pruned by fish or midge larvae. Since midge larvae are scarce at Lake Toba, damage was first believed due to fish or other vertebrates. Upon returning to Lake Toba the following year with some snorkeling equipment, the author was able to discover intact apices on only a few of the hydrilla plants. These tips were bright red in color and extremely brittle, with most of them fragmenting from the plants when removed from the water. Upon splitting perhaps a dozen of these stems, eggs (probably from insects) were found in several of them. The author now feels that the short stature of hydrilla at Lake Toba was due to a pathogen that causes erythrism and fragility in the apical buds. This pathogen is perhaps vectored by ovipositing insects. A serious ear infection prevented any further investigations on the Lake Toba hydrilla. However, in October of 1982 funding was provided for a Malaysian plant pathologist to visit Lake Toba and investigate this possible hydrilla pathogen. Unfortunately, after 2 years he has failed to make these onsite investigations.

## Hydrilla Damaging Insects

72. While the lack of "weediness" by hydrilla in Asia and Australia might be due to environmental conditions, it is unlikely that hydrilla is consistently limited by water quality, nutrient levels, temperature, or other environmental factors over its broad, indigenous geographical range. At many sites, aquatic plants were very common, but hydrilla was only a minor component of the flora. Frequently, the dominant plants were *Potomogeton* spp. and *Najas* spp., which hydrilla readily out-competes in the United States. It is much more likely that hydrilla growth in these areas is constrained by natural enemies. These enemies could include pathogens, insects, fish, and other

Figure 10. Stunted hydrilla, left, from Lake Toba on the Indonesian island of Sumatra. The hydrilla at Lake Toba did not reach the surface and had an unusually sprawling, prostrate growth habit. Other aquatic plants in the immediate vicinity such as Eurasian watermilfoil (*Myriophyllum spicatum*), center, and a pondweed (*Potamogeton* sp.), right, had "normal" growth and appearance. This low growth form of hydrilla may be due to a pathogen which causes the loss of apical buds

organisms. Since population size and structure of many (and perhaps most) species of plants, both terrestial and aquatic, are regulated by insects, insects may control hydrilla growth. Some believe that since hydrilla is a submersed plant and since only a small portion of insects are aquatic, it escapes control by insects. Data emerging from these limited surveys indicate that hydrilla growth is limited by insects. Evidence for this is provided by the great variety of insects already found to damage hydrilla.

73. While only 2,623 insects were found in the 115 hand-search and Berlese collections, the UV light collections provided thousands of additional specimens, most of which remain to be sorted and identified. The author did sort out the herbivorous species from these specimens and these are included in Table 2. This table includes only the specimens from the three insect groups (weevils, ephydrid flys, and moths) which are known to feed on macrophytes. Groups such as caddisflies (Trichoptera) and midges (Diptera: Chironomidae) are not included since it was impractical during these brief

Table 2

Phytophagous Aquatic Insects (Adults) Collected with Ultraviolet Lights in Tropical Asia and Australia (1981-1983)

| Country | Specimens | Number of Species | Collections |
|---|---|---|---|
| Order Coleoptera<br>Curculionidae:*Bagoini*:*Bagous* Plus Other Genera Species (Approximately 18 Species Represented | | | |
| Australia | 113 | 4 | NTR82BL3, NTR82BL4, NTR832Z2, NTR83BL1 |
| Burma | 13 | 3 | BUR82BL1 |
| India | 324 | 10 | KAR81205, KAR81206, KAR82205, KAR82207, KAR82BL1, KAR82BL2, KAR82BL3, KAR82BL4, KAR82BL5 |
| Indonesia | 1 | 1 | SUL82BL1 |
| Thailand | 2 | 1 | PHK82BL1 |
| Order Diptera<br>Ephydridae:*Hydrellia*<br>(Approximately 4-6 Species Represented) | | | |
| Australia | 61 | 1-3 | NTR82BL1, NTR82BL2, NTR82BL4, NTR83201, NTR83202, NTR832Z1, NTR832Z2 |
| India | 41 | 2-3 | KAR82BL1, KAR82BL2, KAR82BL3, KAR82BL4, |
| Order Lepidoptera<br>Pyralidae:*Nymphulinae*:*Parapoynx* Plus Other Genera (Approximately 23 Species Represented) | | | |
| Australia | 170 | 12 | NTR82BL1, NTR82BL2, NTR82BL3, NTR82BL4, NTR83202, QLD82BL1 |
| Burma | 14 | 3 | BUR82BL1, BUR82BL2 |
| India | 57 | 9 | KAR82BL1, KAR82BL2, KAR82BL3, KAR82BL4, KAS83BL3 |
| Indonesia | 26 | 6 | JAV82BL3, LOM82BL1 |
| Malaysia | 8 | 5 | PEN83BL1 |
| Sri Lanka | 3 | 1 | LAN82204 |
| Thailand | 5 | 2 | PHK82BL1 |

surveys to screen the few species which might feed on hydrilla from the many species encountered. Since the insect groups listed in Table 2 include members previously shown to be host-specific to hydrilla, this list can be considered as a compilation of the insect species with the best potential for controlling hydrilla.

74. Of the approximately 20 weevil species collected, most were in the genus *Bagous*. These *Bagous* weevils are of special interest since they usually are host-specific and have short life cycles (C. O'Brien, personal communication), thus making the ideal biocontrol candidates. That weevils can reduce crop yields is well known. *Lissorhaptrus* weevils, which are rice pests, are in the same tribe as *Bagous*, as is *Cyrtobagous*, the weevil being used successfully to control *Salvinia molesta*. Dr. Charlie O'Brien (Florida A&M University), the world's authority on this group, has taken a keen interest in the weevils collected overseas and has agreed to assist in their identification. Many, if not most, of the species collected are undescribed species. Before Dr. O'Brien can assign them names, he must first compare them with the type specimens, most of which are in European museums.

75. Of special interest are the Indian weevils, currently referred to *Bagous* sp. C and *Bagous* sp. E (Figure 11), whose larvae (Figure 12) feed on hydrilla tubers (Figure 13). These were collected in Bangalore India during

Figure 11. A *Bagous* weevil from Bangalore India on a hydrilla tuber. The larvae of this weevil destroy hydrilla tubers. (Photo provided by Dr. Gary Buckingham)

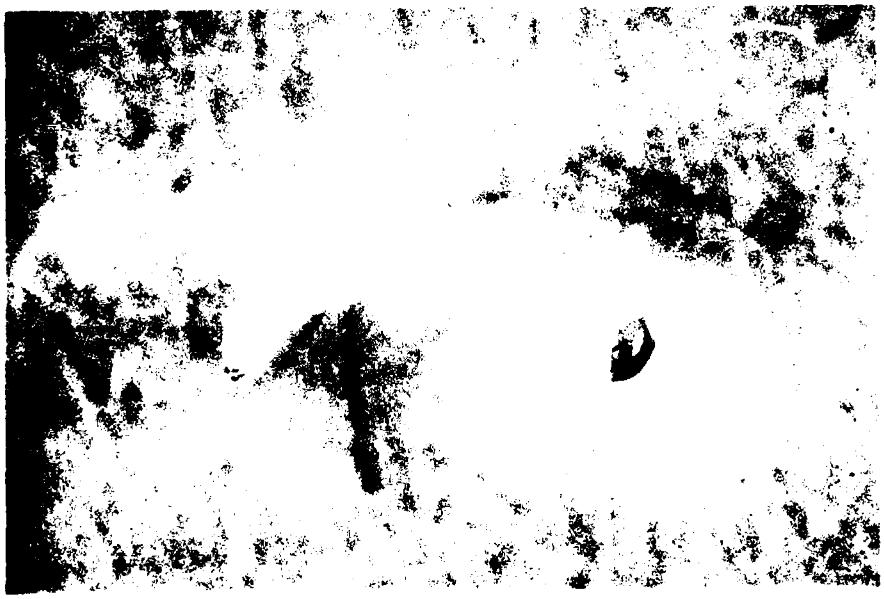


Figure 12. The larva of a *Bagous* weevil

Figure 13. Hydrilla tuber destroyed by larva of *Bagous* sp. C. from Bangalore India (Photo provided by Dr. Gary Buckingham)

the 1982 trip and brought back to the quarantine facilities in Gainesville for further evaluation. After receiving specimens from Pakistan, Dr. O'Brien determined that some of the Indian species were the same as those tested during the hydrilla project in Pakistan. Host testing in the Gainesville quarantine facilities shows that *Bagous* sp. C. is specific to hydrilla, and, at a future date, permission to release this species in the field may be sought (Dr. Gary Buckingham, personal communication).

76. Another insect group showing good potential as biological control agents are the ephydrid flies, especially in the genus *Hydrellia*. *Hydrellia* spp. are tiny flies (Figure 14) whose larvae mine hydrilla leaves (Figure 15) and bore into hydrilla stems. While very small, these leaf miners can be destructive. *Hydrellia griseola* is a serious pest of rice in California and other rice-growing regions of the world (Lange, Ingebretsen, and Davis 1953). Several *Hydrellia* species were tested in Pakistan as potential biological control agents of hydrilla, and *H. pakistanae* was found to be both effective and host-specific (Baloch, Sana-Ullah, and Ghani 1980). During the 1982 visit to India, the author observed that the hydrilla in a small pond near Bangalore was heavily damaged by *Hydrellia*. Within 3 weeks, the hydrilla in this pond had disappeared. These flies were later identified as *H. pakistanae* and it is hoped that this species can be brought to the Gainesville quarantine facility in 1985 for further evaluation.

Figure 14. Life stages of a *Hydrellia* sp. fly. Adult male (top right), adult female (bottom right), late-instar larva (bottom left), and pupa (top right)

Figure 15. *Hydrellia* sp. larvae mining a hydrilla leaf. These larvae, while very small, can be very destructive when they become numerous

77. A major hurdle concerning the further evaluation of this group of flies is the lack of taxonomic expertise. The tropical and Asian members of this genus and family are very poorly known. Most of the ephydrids collected remain unnamed and are probably new to science. The expert for this group has indicated a reluctance to commit the extensive time and energies required to identify the specimens.

78. A third group of insects with potential to control hydrilla are the aquatic moths in the family Pyralidae. The caterpillar of *Parapoynx diminutalis* (Figure 16), referred to by other authors as *Nymphula diminutalis*, was common in South Asia and widespread throughout Southeast Asia. A similar species, *P. diminutalis* (Figure 17), was found in northern Australia. These *Parapoynx* spp. cause the most easily observed damage to hydrilla, and when present in large numbers, completely defoliate the plant. *Parapoynx diminutalis* was found in the United States in 1975 (Del Fosse, Perkins, and Steward 1976), probably cointroduced with hydrilla, and is now widespread in Florida and already negatively impacting hydrilla at some locations (Balciumas and Habeck 1981).

Figure 16. Caterpillar of *Parapoynx diminutalis*, a pyralid moth widespread throughout Asia. This larva has been removed from its case of hydrilla leaves to better show its branched gills

Figure 17. The caterpillar of an Australian aquatic moth, probably *Parapoynx dicentra*. These larvae feed on hydrilla leaves

79. Many other species of caterpillars in genera other than *Parapoynx* (Figure 18) were also collected. Their potential for controlling hydrilla remains to be evaluated.

Figure 18. The caterpillar of a Philippine aquatic moth. This specimen represents one of the many species other than *Parapoynx* which were collected on hydrilla during this survey

## Comparison with Domestic Survey

80. A comparison of the results of these overseas surveys with the domestic survey of hydrilla (Balciunas and Minno 1984) is appropriate. While the overseas surveys were broader in geographic coverage, the domestic survey was quantitative and much more intensive. The domestic survey resulted in 17,358 insect specimens while the overseas survey netted 2,623 insect specimens (from the rake and berlese funnel collections). While the domestic list of hydrilla-damaging insects is composed of 15+ species (Table 1; Balciunas and Minno 1985), Table 2 in this report notes more than 45 species. Moreover, the domestic survey includes groups (aphids, caddisflies, and midges) which are not included in the overseas survey. Thus, only 7 domestic moth and ephydrid species can be compared with the overseas list.

81. While a large complex of weevils, mostly *Bagous* spp., were found feeding on hydrilla overseas, none attack it in the United States. Six

species of moths, only two of which commonly feed on hydrilla, were found in the intensive domestic survey. Over 20 species were recorded during the brief overseas surveys. *Hydrellia* flies were found both here and overseas. However, a greater variety of *Hydrellia* species attack hydrilla overseas and their damage is frequently noticeable, unlike here where *Hydrellia* is usually extremely difficult to detect.

82. Simply stated, hydrilla here in the United States has a much less diverse complex of insect natural enemies when compared with hydrilla overseas. This is probably the major reason why hydrilla is such a noxious weed in the United States, while it displays few "weedy" characteristics in the overseas survey areas. This comparison shows the need for introducing biological control agents for hydrilla. It also indicates that these agents would have a good chance of becoming established. They would fill "vacant niches" and thus not compete directly with native insects.

## PART V: CONCLUSIONS AND RECOMMENDATIONS

83. Approximately 45 insect species showing potential as biological control agents of hydrilla have been recorded during the 15 months of this overs as exploration. Compared with other biological control projects, these surveys have been extensive in geographical coverage but very brief in duration. Compiling a list of an exotic weed's natural enemies typically involves several overseas-based scientist-years. Thus, the list of insects from the present survey is admittedly incomplete. More intensive surveying in the areas already visited and expansion of the search to other areas where hydrilla is native, would undoubtedly multiply the number of candidate species.

84. However, even with the brief nature of the present surveys, certain conclusions can be drawn. Hydrilla is obviously not usually a problem plant in Asia or Australia. This absence of dense monocultures is an indicator of the presence and effectiveness of natural enemies. The insect enemies of hydrilla overseas are varied and numerous, as evidenced by the many species collected during these brief surveys. The intensive domestic survey of hydrilla indicated that only one naturalized and a handful of native insect species presently attack hydrilla in the United States. The classical biological control approach of introducing the natural enemies of a weed into the area where the weed has become established has an excellent chance of controlling hydrilla.

85. The numbers of insect enemies of hydrilla found overseas are already large enough that overseas evaluation of some of the more promising species should begin. Those species for which sufficient information is available should be further tested in quarantine facilities for possible release in the United States. Two species of weevils are currently in quarantine and a *Hydrellia* fly should be imported in 1985.

86. The control of hydrilla in the United States by insects is feasible but will probably require a complex of insects. These should include defoliators, leaf-miners, stem-borers, and tuber feeders. No single insect species is likely to match the range of habitats and environments under which hydrilla already occurs in the United States. Making sound, scientifically based decisions of which insects to study and import, and where these insects should be collected and evaluated, will require a more complete list of insect

natural enemies of hydrilla, and more extensive knowledge of their biology and ecology. Thus, more intensive surveys should be conducted at areas previously visited, where the initial surveys were limited by weather, lack of time, or other factors. Some of the more promising areas include Sri Lanka, Kashmir, Central Burma, and the Philippines. The search should also be expanded to areas where hydrilla is known to be native but which have not been surveyed. This would include Nepal, northern Thailand, China, Korea, and Japan. The need for surveys in these temperate areas has increased with the spread of hydrilla to the Washington, D.C., area and other northern locations.

87. The information provided by these additional surveys would allow future decisions to be based on facts rather than scanty evidence and speculation.

88. As in the past, the pace of progress in the program for the biological control of hydrilla by insects will be primarily controlled by the level of funding. While continuing the funding for foreign exploration at current levels quarantees some overseas work and allows for a slow trickle of insects into quarantine, the time period for successful control of hydrilla in the United States is pushed far into the future, perhaps 10 to 15 years. This time span could be shortened considerably, perhaps even halved, if funding were increased to allow for intensive work. An optimal level, similar to the successful efforts on waterhyacinth and alligatorweed, would allow for two or three full-time scientists to conduct overseas research. Since these surveys have demonstrated that biological control of hydrilla by insects is not only feasible, but probable, an increase in total efforts to higher levels is needed and justified.

89. Recommendations can be summarized as follows:

- a. Begin overseas evaluation of insect enemies of hydrilla already discovered.
- b. Begin quarantine studies of previously evaluated insects.
- c. Intensify surveys and testing in areas previously found promising, but where testing was limited by weather, lack of time, or other factors, e.g., Sri Lanka, Kashmir, Central Burma, Philippines.
- d. Expand searches to new areas, e.g., Nepal, China, northern Thailand, Far East.
- e. Investigate possible hydrilla pathogen at Lake Toba, Sumatra, Indonesia.

*f*. Recognize, in future planning, the probable need for introduction of multiple insect species before effective control is achieved.

*g*. Stabilize program by making financial commitments for the long time period (i.e., 10 years) required by most successful biological control programs.

*h*. Expand program to levels comparable with other biological control projects.

90. The outlook for control of hydrilla in the United States is promising. Despite previous misgivings, these brief surveys indicate that hydrilla in its native range has many enemies. Hydrilla in the United States has very few. It is highly likely that some of the many enemies already found, as well as some of those discovered in the future, will be sufficiently host-specific and damaging to allow them to be released in the United States. The vast amounts of hydrilla in the United States, along with the absence of potential native competitors, makes it likely that these introduced insects will become established and will be effective in reducing hydrilla infestations.

## REFERENCES


Balciunas, J. K. 1982. "Overseas Searches for Insects for Control of Aquatic Plants. Proceedings, 16th Annual Meeting, Aquatic Plant Control Research Program; November 1981, St. Paul, Minn., Miscellaneous Paper A-82-3, US Army Engineer Waterways Experiment Station, Vicksburg, Miss., pp 141-154.

__________. 1983. "Overseas Searches of Insects on Hydrilla," Proceedings, 17th Annual Meeting, Aquatic Plant Control Research Program, November 1982, Sacramento, Calif., Miscellaneous Paper A-83-3, US Army Engineer Waterways Experiment Station, Vicksburg, Miss., pp 104-114.

__________. 1984. "Overseas Surveys of Biocontrol Agents for Hydrilla," Proceedings, 18th Annual Meeting, Aquatic Plant Control Research Program, November 1983, Raleigh, N. C., Miscellaneous Paper A-84-4, US Army Engineer Waterways Experiment Station, Vicksburg, Miss., pp 76-84.

Balciunas, J. K., and Center, T. D. 1981. "Preliminary Host Specificity Tests of a Panamanian *Parapoynx* as a Potential Biological Control Agent for Hydrilla," Environmental Entomology, Vol 10, No. 4, pp 462-467.

Balciunas, J. K., and Habeck, D. H. 1981. "Recent Range Extension of a Hydrilla-Damaging Moth, *Parapoynx diminutalis* (Lepidoptera:Pyralidae)," The Florida Entomologist, Vol 64, No. 1, pp 195-196.

Balciunas, J. K., and Minno, M. K. 1984. "Quantitative Survey of the Insects and Other Macrofauna Associated with Hydrilla," Miscellaneous Paper (accepted), US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

__________. 1985. "Insects Damaging Hydrilla in the U.S.A.," Journal of Aquatic Plant Management (accepted).

Baloch, G. M., Sana-Ullah, and Ghani, M. A. 1980. "Some Promising Insects for the Biological Control of *Hydrilla verticillata* in Pakistan," Tropical Pest Management, Vol 26, No. 2, pp 194-200.

Blackburn, R. D., Boyer, K. A., and Timmer, C. E. 1971. "Phytotoxicity of Four Formulations of the Alkylanine Salt of Endothal on *Hydrilla verticillata* and Fish," Hyacinth Control Journal, Vol 9, No. 1, pp 55-58.

Bowes, G., Holaday, A. S., Van, T. K., and Haller, W. F. 1977. "Photosynthetic and Photorespiratory Carbon Metabolism in Aquatic Plants," Proceedings, 4th International Congress on Photosynthesis, Reading, W. Va., pp 289-298.

Burkhalter, A. 1977. "Hydrilla Research and Control," Proceedings, Research Planning Conference on the Aquatic Plant Control Program, October 1977, New Orleans, La., pp 101-102.

Campbell, H. W., and Irvine, A. B. 1977. "Feeding Ecology of the West Indian Manatee (*Trichechus manatus* Linnaeus)," Aquaculture, Vol 12, No. 3, pp 249-251.

Charudattan, R., Freeman, T. E., Cullen, R. E., and Hofmeister, F. M. 1980. "Evaluation of *Fusarium roseum* "Culmorum" as a Biological Control for *Hydrilla verticillata*," Abstracts of papers presented at the V International Symposium on Biological Control of Weeds, July 1980, Brisbane, p 7.

Charudattan, R., Freeman, T. E., Cullen, R. E., and Hofmeister, F. M. 1983. "Status of the Fungii *Cercospora* and *Fusarium*, for Aquatic Plant Control," Proceedings, 17th Annual Meeting, Aquatic Plant Control Research Program, November 1981, Sacramento, Calif., Miscellaneous Paper A-83-3, US Army Engineer Waterways Experiment Station, Vicksburg, Miss., pp 115-120.

Cook, C. D. K., and Luond, R. 1982. "A Revision of the Genus *Hydrilla* (Hydrocharitaceae)," Aquatic Botany, Vol 13, pp 485-504.

Del Fosse, E. S., Perkins, B. D., and Steward, K. K. 1976. "A new U.S. Record for *Parapoynx diminutalis* (Lepidoptera:Pyralidae), A Possible Biological Control Agent for *Hydrilla verticillata*," Florida Entomology, Vol 59, pp 19-20.

Ewel, K. C., and Fontaine, T. D., III. 1982. "Effects of White Amur (*Ctenopharngodon idella*) on a Florida Lake: A Model," Ecological Modelling, Vol 16, pp 251-273.

Gale Research. 1983. "Climate Normals for the U.S. (Base: 1951-80)," Detroit, Mich.

Ghani, M. A. 1976. "Insects and other Phytophagous Organisms which Attack Florida Elodea (*Hydrilla verticillata*) in Pakistan," Final Report, Commonwealth Institute Biological Control, Pakistan Station, Rawalpindi, Pakistan.

Guerra, L. V. 1977. "*Hydrilla* in Texas," Proceedings of the 30th Annual Meeting of the Southern Weed Science Society, p 335.

Haller, W. T. 1982. "Hydrilla Goes to Washington," Aquatics, pp 6-7.

Haller, W. T., and Sutton, D. L. 1975. "Community Structure and Competition between *Hydrilla* and *Vallisneria*," Hyacinth Control Journal, Vol 13, pp 48-50.

Hartog, C. den. 1973. "Family 5A, Hydrocharitaceae," Flora of Panama, Part II, Ann. Missouri Bot. Gard., Woodson, R. E., Jr., and Schery, R. W., Eds., Vol 60, pp 7-15.

Lange, W. H., Jr., Ingebretsen, K. H., and Davis, L. D. 1953. "Rice Leaf Miner: Severe Attack Controlled by Water Management, Insecticide Application," California Agriculture, Vol 7, No. 8, pp 8-9.

Legner, E. F. 1979. "Update of Biological Aquatic Weed Control with Fish in Irrigation Canals in California's Lower Desert," Abstracts of 1979 Meeting of the Weed Science Society of America, pp 62-63.

Mahler, M. J. 1979. "Hydrilla the Number One Problem," Aquatics, Vol 1, pp 56.

Osborne, J. A. 1982. "Efficacy of Hydrilla Control and a Stocking Model for Hybrid Grass Carp in Freshwater Lakes," Final Report to Office of Exploratory Research, US Environmental Protection Agency, Washington, D.C.

Osborne, J. A., and Sassic, N. M. 1979. "Biological Control of *Hydrilla verticillata* Royle with Grass Carp (*Ctenopharyngoden idella* Val.)," Journal of Aquatic Plant Management, Vol 17, pp 45-48.

Pemberton, R. W. 1980. "Exploration for Natural Enemies of *Hydrilla verticillata* in Eastern Africa," Miscellaneous Paper A-80-1, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Pierce, B. A. 1983. "Grass Carp Status in the United States: A Review," Environmental Management, Vol 7, No. 2, pp 151-160.

Rao, V. P. 1969. "Evaluation of Natural Enemies Associated with Witchweed, Nutsedge and Several Other Aquatic Weeds Occurring in India," US PL-480 Project, Technical Report.

Rao, V. P., and Sankaran, T. 1974. "Evaluation of Natural Enemies Associated with Witchweed, Nutsedge and Several Other Aquatic Weeds Occurring in India," US PL-480 Project, Final Technical Report.

Room, P. M., Harley, K. L. S., Forno, I. W., and Sands, D. P. A. 1981. "Successful Biological Control of the Floating Weed *Salvinia*," Nature, Vol 294, No. 5836, pp 78-80.

Sainty, G. R., and Jacobs, S. W. L. 1981. "Waterplants of New South Wales," New South Wales Water Resources Commission.

Speke, J. H. 1864. Journal of the Discovery of the Nile, 2nd edition, Blackwood and Sons, Edinborough.

Sutton, D. L. 1977. "Grass Carp (*Ctenopharyngoden idella* Val.) in North America," Aquatic Botany, Vol 3, No. 2, pp 157-164.

Tarver, D. P., Rodgers, J. A., Mahler, M. J., and Lazor, R. L. 1978. "Aquatic and Wetland Plants of Florida," Bureau of Aquatic Plant Research and Control, Florida Department of Natural Reosources, Tallahassee, Fla.

Varghese, G., and Singh, G. 1976. "Progress in the Search for Natural Enemies of *Hydrilla* in Malaysia," Aquatic Weeds in S. E. Asia, Proceedings of a Regional Seminar on Noxious Aquatic Vegetation, New Delhi, 1973, W. Junk, The Hague, Netherlands, pp 341-352.

# APPENDIX A: CHRONOLOGY OF FOREIGN SEARCHES FOR INSECT ENEMIES OF HYDRILLA

1968 Hydrilla added to list of aquatic plants whose natural enemies are being investigated by Commonwealth Institute of Biological Control (CIBC) scientists in India.

1969 Rao, CIBC, reports that *Parapoynx diminutalis* is the most common and damaging insect natural enemy of hydrilla in India.

1971 CIBC initiates search for insect enemies of hydrilla in Pakistan.

1973 Varghese begins studies of insect enemies of hydrilla in Malaysia.

1973 Baloch and Sana-Ullah present preliminary report on natural enemies of hydrilla in Pakistan. Of the eight insect species and two snail species found, only the ephydrid fly *Hydrellia* sp., the moth *Parapoynx diminutalis*, and the weevil *Bagous* sp. nr. *limosus* are considered to be promising biocontrol agents and are being studied further.

1975 DelFosse et al. discover *Parapoynx diminutalis* in Fort Lauderdale, Fla. This Asian species probably accidentally introduced in a shipment of aquarium plants.

1975 Allen searches in Africa and Indonesia for insect enemies of hydrilla. Results not reported.

1976 Varghese and Singh present final report on studies in Malaysia. Only two insect enemies recorded. One, an aphid species, attacked hydrilla only in greenhouse culture. The other species, a moth, probably *Parapoynx diminutalis*, appears to be fairly specific to hydrilla.

1976 Baloch and Sana-Ullah submit final report on insect enemies of hydrilla in Pakistan. The biology and host-specificity of the three most promising biological control candidates have been studied. A *Bagous* species weevil which feeds on hydrilla tubers is fairly specific. *Parapoynx diminutalis* feeds and reproduces on several aquatic plant species. The leaf-mining *Hydrellia* sp. appeared to be quite specific to hydrilla, but it also fed on *Potamogeton* spp.

1976 Pemberton and Lazor conduct search in Africa for insect enemies. Hydrilla not found until late in 3-month survey and only one possible enemy, the larvae of a midge (Chironomidae), probably in the genus *Polypedilum*, is recorded.

1978 Sanders and Theriot discover a moth, later identified as *Parapoynx rugosalis*, damaging hydrilla in the Panama Canal Zone.

1979 Balciunas and Center study *Parapoynx* prob. *rugosalis* in Panama and find that it feeds primarily on hydrilla and *Najas*.

1980 Buckingham receives permission to bring Panamanian *Parapoynx* into quarantine facilities in Gainesville for further testing. However, the species collected by Sanders and Theriot and tested by Balciunas and Center can no longer be located in Panama.

1981 CIBC begins search for insect enemies of hydrilla in East Africa. Initial searches indicate hydrilla is not present in Kenya.

1982 Habeck and Bennet make two unsuccessful trips to Panama searching for *Parapoynx rugosalis* and the *Parapoynx* sp. tested by Balciunas and Center.

1983 Markham (CIBC) begins studies of insects attacking hydrilla in Burundi, Rawanda, and Tanzania.

## APPENDIX B: PRETRIP QUESTIONNAIRE SENT TO POTENTIAL FOREIGN COOPERATORS AND SUMMARY OF RESPONSES RECEIVED

1. Do you have temporary laboratory space for visiting researchers? (Space for small scale rearings, preparation of specimens, microscope dissections, etc.) If so, are there charges for the space?

RESPONSE: India. "Yes. We charge a bench fee of 35 pounds per person per week." (T. Sankaran, Entomologist-in-charge, Commonwealth Institute of Biological Control (CIBC))

Thailand. "NBCRC is adequately equipped with basic laboratory necessities that will enable a visiting scientist to carry out his work comfortably. Normally, there is no charge as long as the facility can be utilized for cooperative purposes. Similar facilities on a relatively limited scale could be arranged with NBCRC counterparts in key areas of the country such as Haad Yai in the south close to the Songkhla Lake where numerous aquatic weed problems occur." (B. Napompeth, Director, National Biological Control Research Center (NBCRC))

Indonesia. "Yes, we have." (I. Soerianegara, Director, Biotrop)

Malaysia. No response.

2. Can you suggest research locations in your country or others that should be contacted? (We are contacting CIBC-India, NBCRC-Thailand, BIOTROP-Indonesia, and ARDI-Malaysia)

RESPONSE: India. "None in India working on biocontrol aspects of Hydrilla using organisms other than the white amur."

Thailand. "U Mya Maung, Agriculture Corporation, Rangoon, Burma. Burma is probably a good place for exploration. However, laboratory facilities and others are relatively limited. Also, there is a limitation as to travel in the country side."

Indonesia. "We will be very glad if your team could conduct the research in Indonesia. You could observe some lakes and ponds invested by *Hydrilla verticillata*."

Malaysia. No response.

3. What would be the approximate costs for living quarters for a scientist (2 months)? Are apartments or bungalows available? Hotels?

RESPONSE: India. "It is difficult to fix up apartments or bungalows for two months. Hotel accommodations can easily be booked in advance, offering a monthly rate. U. S. $150-200 per month should be a reasonable provision for such accommodation."

RESPONSE: Thailand. "A medium class hotel in Bangkok will cost about $15 per day. A monthly rental could be arranged. An apartment is also available but lease is required and it could be more expensive on a short term basis, in addition to difficulty in finding the more suitable one."

Indonesia. "BIOTROP has living quarters for her guests and trainees, usually two persons stay in a room with twin-beds. BIOTROP charges Rp. 8.000, = U. S. $15 per day per person for daily meals and room service (not including laundry service). Hotels or bungalows are available in the city."

Malaysia. No response.

4. Can you roughly estimate high-low costs of daily meals?

RESPONSE: India. "Three meals - American/European menu. U. S. $12-15 daily
Indian mean U. S. $5 daily
Drinks are not included in these rates."

Thailand. "An average meal for the local Thais are cheap not exceeding $3.00 per day. A maximum of $10.00 per day for meals will be more than adequate. However, it is also possible to spend as much as $25.00 for a very good meal as well."

Indonesia. "For a scientist, daily meals would be U. S. $5-6.5."

Malaysia. No response.

5. Does your institute provide rental vehicles? Costs? Costs of local rentals?

RESPONSE: India. "Local drivers are available only with drivers. A monthly minimum mileage (16,000 km)[?] must be guaranteed by the hirer. Rates approximately U. S. 20-25¢ per km, subject to some 'bargaining'. CIBC may be able to rent a car without driver for about 30¢ a km. No mileage prescribed but since we only have one car its availability is limited and has to be arranged by prior notice. Indian roads have left-hand traffic and driving conditions are not at all pleasant."

Thailand. "We have two vehicles, a Land Rover jeep and a Toyota Hiace van. The jeep can be provided for field trips. We might request for gas, maintenance and other mechanical work if needed. A driver is also available and on a field work a daily subsistence allowance (DSA) of about $6 is required."

Indonesia. "No BIOTROP does not have rental vehicles. You could rent a private vehicle. The cost of local rental car would vary from U. S. $35.00-40.00 per day."

Malaysia. No response.

6. Approximately what would it cost to hire a field helper? A laboratory helper for rearing or biologies?

RESPONSE: India. "It is difficult to hire skilled helpers for a month or two. If available, a skilled assistant may be paid U. S. $100 per month and an unskilled helper $40-50 per month.

Thailand. "A field helper will cost about $150 per month and on a field trip a DSA of $10.00 for a helper with a B.S. A native helper will be $75.00 per month on a DSA of $6.00 per day on a field trip. It is possible to assign one of the staff members to assist in the project and an honorarium might be necessary as an incentive."

Indonesia. "The cost for a field helper varies from U. S. $1.80-3.20 per day. The cost for a laboratory helper varies from U. S. $4.00-8.00 per day."

Malaysia. No response.

7. Do you know of any special restrictions on field work and collecting by visiting scientists, or necessary permits?

RESPONSE: India. "No special restrictions on field work by foreign nationals except in "sensitive areas" like border districts, Himalayan region, etc. Permits not needed for a few museum specimens taken out for scientific research. Shipments of living Lepidoptera, endangered species is prohibited by law.

Thailand. "National Research Council of Thailand which NBCRC is a part of does require foreign visiting scientists to register. However, this should not be considered as any restriction to deter foreign scientists to work in Thailand. In general, working in Thailand will be very pleasant once one can get used to the heat. No restriction on field work has been imposed. It is suggested, however, that one should not roam too close to certain sensitive areas."

Indonesia. "We advise you to request a permit to the Indonesian Institute of Sciences (LIPI), Jl. Chik Ditiro 43, Jakarta Pusat, Indonesia."

Malaysia. No response.

8. What months do you feel would be best for field work on aquatic weeds?

RESPONSE: India. "The period depends on the area - north India, south India, plains, higher elevations, etc. Generally, in south India, September-November (after the monsoon rains) would be a suitable time."

Thailand. "Any time of the year after the monsoon season is over in November. The peninsular area is somewhat different but it should not cause much of an inconvenience."

RESPONSE: <u>Indonesia.</u> "We suggest to do the field work on aquatic weeds during the dry season (April-September)."

<u>Malaysia.</u> No response.

## APPENDIX C: EXAMPLE OF DATA SHEET USED DURING FOREIGN SURVEYS

COLLECTION NUMBER ____________ PLANT SPECIES SAMPLED ____________________

COLLECTION METHOD ________________________________________________

COUNTRY ________________________________________ DATE ____________

COLLECTOR(S) ________________________________________________

SITE NAME ________________________________________________

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TIME | ______ | SUNNY | ______ | DRY | ______ | CALM | ______ |
| SUNRISE | ______ | CLOUDY | ______ | SPRINKLES | ______ | BREEZY | ______ |
| SUNSET | ______ | OVERCAST | ______ | DRIZZLE | ______ | WINDY | ______ |
| MOON PHASE | ______ | DARK | ______ | SHOWERS | ______ | | |

STATE OR PROVINCE ____________________ COUNTY OR DISTRICT ____________________

LATITUDE ______° ______' ______"

LONGITUDE ______° ______' ______"

ELEVATION ______

NEAREST VILLAGE ____________________ DISTANCE TO SITE ________ DIRECTION TO SITE ________

NEAREST MAJOR CITY ____________________ DISTANCE TO SITE ________ DIRECTION TO SITE ________

TYPE OF WATER BODY ____________ SIZE ____________ SUBSTRATE ____________

| AQUATIC PLANT SPECIES | ABUNDANCE (% COVER) | DEPTH OF UPPER TIPS | WET WEIGHT | DRY WEIGHT |
|---|---|---|---|---|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| 5. | | | | |
| 6. | | | | |

SAMPLING POINT DEPTH ________ DISTANCE TO SHORE ________ SECCHI DISK TRANSPARENCY ________

| | SURFACE | BOTTOM |
|---|---|---|
| TEMPERATURE | ______ | ______ |
| SALINITY | ______ | ______ |
| CONDUCTIVITY | ______ | ______ |
| PH | ______ | ______ |
| NITRATES | ______ | ______ |
| PHOSPHATES | ______ | ______ |
| | ______ | ______ |
| | ______ | ______ |

| KIND | NUMBER |
|---|---|
| COLEOPTERA | ______ |
| DIPTERA | ______ |
| LEPIDOPTERA | ______ |
| TRICHOPTERA | ______ |
| ______ | ______ |
| ______ | ______ |

INSECT ABUNDANCE ____________

HABITAT DESCRIPTION ________________________________________________

________________________________________________

REMARKS ON PLANT POPULATIONS AND GROWTH ____________________

________________________________________________

NOTES ________________________________________________

________________________________________________

________________________________________________

# APPENDIX D: TRAVEL LOG FOR 1981 (21 JUNE - 23 OCTOBER) OVERSEAS HYDRILLA SURVEY

21-22 June--Traveled from Fort Lauderdale to Zurich.

22-25 June--Met with Dr. C. D. K. Cook, Director, Zurich Botanical Gardens. Dr. Cook showed me the botanical gardens, the collection of aquatic plants and other facilities. We discussed the distribution of hydrilla in Asia and elsewhere and how to distinguish hydrilla from aquatic plants similar in appearance. He graciously provided me locations of hydrilla from herbaria specimens cited in his forthcoming monograph on *Hydrilla*. Hydrilla is very common in India, especially the southern portion and he believes this would be a good area to search for natural enemies although he does not recall ever seeing any "moth-eaten" hydrilla. He showed me slides of hydrilla and other aquatic plants in Kerala State (on the southwest coast of India). He also provided me with a list of former students now in Asia who might be able to offer me assistance.

25-26 June--Traveled to New Delhi, India.

26-29 June--Met with Dr. Stanley Stone, Director, US Department of Agriculture (USDA), Far Eastern Regional Research Organization (FERRO), who advised me on medical and other precautions necessary for health and safety while in India. Expressed great interest in biological control of aquatic weeds and would be glad to see substantial amount of PL-480 monies devoted to a project in this area.

To acquaint me with the problems and procedures in initiating PL-480 projects he let me study the files of current and previous PL-480 projects in India. It appears that the Indian government is reluctant to approve new cooperative projects since this entails large monetary appropriations on their part. Also, ongoing projects are frequently delayed or suspended when one of the Indian principal investigators leaves the project to take a position elsewhere.

29 June--Traveled to Bangalore. (See Figure 1 for location.)

30 June-5 July--Met with Dr. T. Sankaran, head of Indian Commonwealth Institute of Biological Control (CIBC) Station. We discussed my current project and previous related work in this area, in which he is quite knowledgeable. He stated that Mr. W. Rex Ingram had been selected to head up the new CIBC Laboratory in Kenya. USDA has a contract with CIBC for a survey of natural enemies of hydrilla in Africa, but research is not expected to begin there until next year (1982). Dr. Sankaran also provided me with reports of past PL-480 projects concerning aquatic weeds in India. He does not believe that a new PL-480 project on aquatic weeds stands much of a chance of approval by the Indian government. He was turned down by them recently on a proposal for biological control of waterhyacinth. However, he believes that embassy PL-480 monies might be used to assist me in my survey. He and his assistants would collect insects and other data; they could also do life history studies, feeding tests, etc. He would then ship the specimens and data and send the bill to the US Embassy in New Delhi who would pay CIBC with PL-480 monies. While the costs per shipment would be relatively high, since CIBC must charge for

all costs (hourly rate for technicians, vehicle costs, overhead, etc.), we would obtain a lot of information with no additional expense to our research budget. He is currently doing the same sort of thing with natural enemies of scales. A similar arrangement might be possible to pay for my use of a CIBC vehicle on a future extended collecting trip.

I spent a couple of days collecting insects on hydrilla at six different locations within 120 km of Bangalore. Although the monsoon usually begins in May in the Bangalore area, it appeared to "have failed" in 1981. While many ponds which may have had hydrilla were now completely dry, many of the more permanent bodies of water were infested and the hydrilla was easy to observe and collect. Although only a short time (approx. 1 hr) was spent searching through the hydrilla at each site, many insects, including some causing damage, were found. Moth larvae similar to *Parapoynx diminutalis* were present at most sites. It was very common in the pools of a dried-up stream where more than 50 percent of the stems had larval (or pupal) cases. A few larvae of another nymphuline, probably *Nymphula* sp., were also collected.

Small weevils comprising at least two species of *Bagous* were found on hydrilla and appeared to be feeding on it. Weevil larvae, probably also *Bagous* spp., were found boring in hydrilla stems. Since *Bagous* spp. are usually very host-specific and since they significantly damage hydrilla, they should be investigated further for importation to the United States as possible biological control agents on hydrilla. Dr. Sankaran agreed to ship the plant and insect specimens back to the United States for me.

5 July--Traveled to New Delhi.

6 July--Attempted to meet with Dr. Stone to discuss use of PL-480 money for specimens, but Embassy was closed for July 4th holiday.

7 July--Traveled to Calcutta. Plane departed 4 hr late. Missed connection to Rangoon.

8-9 July--Stranded in Calcutta waiting for next flight to Rangoon.

9 July--Traveled to Rangoon, Burma.

10 July--Met with Mr. Eugene Dorris, Science Officer, and Mr. Saw Laik, Agricultural Advisor, at the US Embassy Rangoon. Mr. Dorris explained that Burmese government officials must have permission for the Burmese Foreign Minister before meeting with foreigners. It usually takes 2 months to obtain this permission. All Burmese scientists working at Universities, Agriculture Department, and elsewhere are government employees and therefore cannot have "official" contact with me. Mr. Saw Laik took me to meet "unofficially" with several professors from Rangoon University who are personal friends of his.

11-12 July--Visited aquatic sites in Rangoon vicinity with Mr. Saw Laik and Mr. Hia Yint Hpu. Guides are essential since many areas are considered "sensitive," e.g., a government official lives in vicinity, and any unauthorized person faces severe interrogation. Hydrilla was present at only one site, Lake Inya, and it showed very little damage from insects or other organisms.

Alligatorweed, however, was severely attacked by a chrysomelid beetle, with both the adults and larvae feeding on it.

13 July--Met with Mr. Terry Crowe and Mr. Hugh Rendell, United Nations Food and Agricultural Organization (FAO). While not presently involved with aquatic plants, they were interested in biocontrol of pest species, especially waterhyacinth. They agreed to collect aquatic plants and associated insects, especially if we send them information so they can tell what kind of plants they are collecting. In the afternoon, met with Mr. U. Percy Mao, Chief Engineer of Water and Sewer Division. The US Embassy believed he was interested in controlling waterhyacinth. After talking with him, I learned that he is concerned with "underwater waterhyacinth," actually hydrilla. Unfortunately, we cannot help him with that now. Floating waterhyacinth, *E. crassipes*, "...is no problem" since they remove it manually.

14 July--Traveled to Mandalay, Burma.

14-15 July--Searched for hydrilla and associated insects in Mandalay-Sagaing area with Mr. Mya Maung. There is a very old (1826) herbarium record of hydrilla from here, but due to heavy monsoon rains there had been heavy flooding and hydrilla was not present in flooded areas. There were patches of hydrilla in the 8-km-long moat surrounding Mandalay Fort. This hydrilla also showed little evidence of feeding damage, but appeared to be infected possibly by a pathogen since the leaves and stems were very brittle and fractured with very slight pressure. The most common aquatic plant in Mandalay Moat was coontail, *Ceratophyllum* sp.

15 July--Returned to Rangoon.

16 July--Traveled to Bangkok, Thailand.

16 July--Met with Dr. Banpot Napompeth, Director, National Biological Control Research Center (NBCRC). Discussed project goals and related research.

17-18 July--Inspected aquatic nuisances at lakes 200 km north and 150 km east of Bangkok. Hydrilla was not present at these locations. Main problem plants are *Mimosa pigra*, *Eichhornia crassipes*, and *Ceratophyllum*. *Mimosa pigra* was introduced into Thailand for erosion control, but it has now become a serious problem in aquatic and semiaquatic areas.

20 July--Inspected NBCRC facilities and met personnel. Mr. Wiwat showed slides of moth, *Episammia pectinicornis*, specific to waterlettuce, *Pistia stratiotes*, and as effective as herbicide in removing *Pistia*. This moth should receive serious consideration for importation to the United States and Panama as a biological control agent for *Pistia*. In the afternoon, met Ms. Saewanee Thamsara, head of Thailand Department of Irrigation. She is quite knowledgeable about aquatic plants. Knows many locations in Thailand where hydrilla is present, but most are in northern Thailand. Made appointment for one of her assistants to take me to a hydrilla infestation 200 km south of Bangkok tomorrow. She had many species of aquatic plants growing in concrete pools behind her office. In one pool, we found a moth larvae, similar to *P. diminutalis*, on hydrilla although it appeared to be more abundant on the *Potomageton* sp. also growing in the same pool.

21-22 July--Came down with very severe diarrhea. It took 2 days, spent in bed, before my old standby, lomotil, started having any effect.

23 July--Traveled to Kuala Lumpur, Malaysia. Felt better so decided to leave for Kuala Lumpur as scheduled. If necessary, would prefer to be hospitalized in Kuala Lumpur rather than Bangkok.

24-26 July--Had relapse of diarrhea. Spent 3 more days in bed.

27 July--Discussed my project with Mr. Richard Blabey, US Agricultural Attachee, and with Mr. Raymond Ho, his assistant. Mr. Ho spent most of morning telephoning people in Malaysian Agriculture and Irrigation Departments. Because of holidays (Harl Raya) that weekend, many people were already on leave, and almost everyone and everything would be closed at least the first 2 days of next week. Finally talked to Mr. Baki bin Bakar, at Malaysian Agricultural Research and Development Institute (MARDI) at Bumbong Lima near Penang (about 322 km north of Kuala Lumpur). He had been surveying aquatic weeds, knows where hydrilla is, and promised to see me on Wednesday (July 29) if I can make it up to the station.

28 July--Traveled to Penang.

29 July--Rented car and made 2-hr drive to the MARDI station at Bumbong Lima. Met with Mr. Baki, Dr. Supaad Mohd (head-of-station), and other MARDI staff members. They informed me that several people in the biology department of Malaysia University of Science (USM) were working on biological control of aquatic weeds and I should meet with them. Mr. Baki said that, by far the most important aquatic weed in Malaysia is waterhyacinth. Coontail is the most common submersed plant. Hydrilla appears sporadically at some locations, mostly in northern Malaysia, but there was none nearby which he could show to me.

30 July--Met with Dr. Ivor G. Caunter, Dr. Raj, Dr. Tan, and other faculty at Biology Department USM. Dr. Ivor has a grant to study the utilization and control of waterhyacinth. As a plant pathologist, he has primarily been looking at pathogens of waterhyacinth, but has also enlisted the help of an entomologist colleague, Dr. Raj, to study the insects. He is very interested in extending his study to include hydrilla and he agreed to hire a technician who will collect hydrilla insects and send them to me in the United States.

31 July--Inspected a hydrilla infestation on Penang Island with Dr. Ivor. The hydrilla showed little damage. No insects which might feed on it were found.

2-4 August--Drove rental car from Penang Island on west coast, south through central Malaysia, then to Kuantan on the east coast, then back to Kuala Lumpur. Inspected various aquatic habitats, but no hydrilla was found. Because of the Hari Raya holidays, most hotels were booked and almost a quarter of the total of 1,400 km was driven at night.

5 August--Traveled to Jakarta, Indonesia.

6-8 August--Met with Allan Trick, Dan Conable, and other staff members at the Agricultural Office of the US Embassy in Jakarta. Picked up my mail sent in care of them. The use of APO mail system during my stay in Indonesia was very convenient, since it was relatively fast (around 10 days, one way), dependable, safe, and cheap (government-franked envelopes and mailing labels can be used). Made withdrawal from my suspense-deposit-abroad (SDA) account which had been set up before my departure from the United States. Dr. Karnandi, Assistant Director of SEAMEO Regional Center for Tropical Biology (Biotrop), drove me to the Biotrop headquarters near Bogor, about 60 km from Jakarta. Met with Dr. Ishemat Soerianegara, Director of Biotrop, and other administrators. Met with Mr. Kasno, Biotrop scientist, who has had some experience with biological control of aquatic plants and with whom I would be working. Made arrangements for room and meals at the Biotrop trainee dormitories.

10-21 August--Collecting with Biotrop staff near Bogor and other West Java sites. A moth larvae similar to *Parapoynx diminutalis* was damaging hydrilla at most sites. Caddisfly (Trichoptera) larvae were abundant at one site but did not appear to be damaging hydrilla.

24 August-4 September--Extended collecting trip with Mr. Kasno and Biotrop driver to Central and East Java. Hydrilla infestations are causing problems in new reservoirs and irrigation systems. *Parapoynx diminutalis* damaging hydrilla at all sites. Midge larvae (Chironomidae) found associated with hydrilla at approximately half of the collecting sites, but did not appear to be causing damage. Eggs of a water scorpion (Hemiptera:Nepidae) found inserted into stems of hydrilla at a Central Java site. While this caused hydrilla to fragment more easily, it did not otherwise seem to damage the plant.

7-18 September--Flew to South and North Sumatra with Mr. Aderis, Biotrop technician. Almost 1 week spent collecting at Lake Toba, the largest lake in Southeast Asia, in North Sumatra. A deep (500 m) volcanic lake at an elevation of over 900 m, Lake Toba had a variety of submersed plants, mostly confined to narrow bands along the shoreline. Eurasian watermilfoil, *Myriophyllum spicatum*, and a pondweed, *Potomageton* sp., were the most prominent submersed plants. Waterhyacinth, *Eichhornia crassipes*, was the dominant floating plant, while *Mimosa pigra*, introduced less than 10 years ago, is now well established along the shoreline and in shallow water. While both the milfoil and pondweed reached the surface even from depths exceeding 5 m, hydrilla was usually prostrate on the hydrosoil and could usually be located only by diving. This unusual habit of the hydrilla appeared to be due to severe grazing of the apical portions of the plant (probably by a fish) resulting in a stunted, sprawing plant. Insects at Lake Toba were extremely rare in all samples of the three submersed plant species examined.

*Parapoynx diminutalis* larvae (or a similar species) were damaging hydrilla at all other Sumatra infestations examined. Some sites also had chironomid and Trichoptera larvae associated with the hydrilla. Again, there was no persuasive evidence that either of these were damaging the hydrilla.

21-29 September--Prepared specimens for shipment. Packed collecting and other scientific equipment. Had visa extended. Mailed specimens back to United States. Closed out SDA account at US Embassy.

30 September--Traveled to Denpasar, Bali.

1-3 October--Examined aquatic habitats in Denpasar vicinity for hydrilla. No hydrilla located. Since the monsoon season was just beginning, many aquatic systems were dry. The use of ducks seemed to be quite effective in keeping aquatic weeds controlled in smaller irrigation systems.

5-15 October--Annual leave.

16 October--Minor scratches on leg had become infected and developed into large, open tropical ulcers. Postponed my scheduled flight to Australia since leg was too swollen and painful for travel. Sought local medical attention.

19 October--Infection responded slowly to medication. Decided to skip collecting scheduled for Australia, and return as soon as possible to the United States.

21 October--Left Bali, 6 a.m.

23 October--Arrived in Florida.

APPENDIX E: TRAVEL LOG FOR 1982 (13 APRIL - 24 OCTOBER) OVERSEAS HYDRILLA SURVEY

13 April--Leave Fort Lauderdale.

14 April--Arrive Cairo, Egypt.

15 April--Meetings at US Embassy with Drs. Fayad and Ibrahim. Travel to Alexandria with Drs. Fayad and Ibrahim.

16 April--Inspect aquatic weed problems at Lake Ecedo.

17 April--Return to Cairo.

18 April--Meetings with Dr. Fayad.

19 April--Local holiday - free time

20 April--Meet with Ag. Counselor, US Embassy. Present seminar at Plant Protection Institute. Inspect possible *Neochetina* release sites.

21 April--Travel to Nairobi, Kenya. Meet with Drs. Ingram and Markham.

22 April--Meetings at Maguga Station. Inspect aquatic sites in Nairobi vicinity.

23 April--Charter airplane (5 hr) for flight to Lake Victoria to survey aquatic weeds.

24 April--Maguga station: planning and preparations for trip to Lake Victoria.

25 April--Drive to Kiusa on the east shore of Lake Victoria.

26-28 April--Collecting at Lake Victoria.

29 April--Return to Nairobi.

30 April--Maguga station: pack specimens and equipment; US Embassy.

1-2 May--Travel to Delhi, India.

3 May--Meetings with Far Eastern Regional Research Organization (FERRO) personnel. Travel to Bangalore.

4-5 May--Attend Symposium on Biological Control of Waterhyacinth. Present seminar.

6 May--Recover from food poisoning.

7-31 May--Collect *Bagous* weevils and other insects on aquatic plants in Bangalore area. Host testing and other research at Commonwealth Institute of Biological Control (CIBC) laboratories. Check herbarium records at St. Joseph College for aquatic plants and for *Abutilon*.

1 June--Travel to Colombo, Sri Lanka.

2 June--Meetings at US Embassy, Live Tropical Fish Co. personnel.

3 June--Meetings at Kelaniya University.

4-5 June--Survey for hydrilla insects in Columbo.

6 June--Begin extended survey of Northern and Central Sri Lanka with rental car and driver. Drive to Kala Oya, surveying enroute.

7 June--Tour Willpata National Park, then drive to Anuradhapura.

8 June--Survey Anuradhapura vicinity.

9 June--Drive to Trincomallee, surveying enroute.

10 June--Process samples collected on previous day. Set up rearing tests for *Parapoynx* sp. and *Hydrellia* sp.

11 June--Check rearing tests. Remainder of day, free time.

12 June--Check rearing tests. Remainder of day, free time.

13 June--Drive to Polonura, then Segeryla surveying enroute.

14 June--Drive to Kandy, survey Royal Botanical Gardens.

15 June--Drive to Colombo, surveying enroute.

16 June--Present seminar at Kelaniya University. Meetings with staff. Pack equipment and specimens.

17 June--Travel to Rangoon, Burma.

18 June--Meetings with US Embassy officials.

19 June--Meetings with Dr. T. Crowe, United Nations Food and Agricultural Organization (FAO) and with Embassy officials.

20 June--Travel (by train) to Mandalay.

21 June--Survey in Mandalay vicinity.

22 June--Survey in Meiktila vicinity.

23 June--Leave Mandalay, travel to Taungyl.

24 June--Recover from gastroenteritis.

25 June--Travel and collecting at Inle Lake.

26 June--Collecting at Inle Lake vicinity.

27 June--Leave Taungyii, travel to Rangoon; complete processing previous day's samples.

28 June--Meetings with Embassy officials. Collecting in Rangoon vicinity.

29 June--Process previous day's sample at FAO laboratories.

30 June--Collecting in Rangoon vicinity; process samples at FAO laboratories.

1 July--Meetings at Embassy; pack equipment and specimens. Travel to Bangkok.

2 July--Meetings at Embassy; visa applications for Indonesia and Australia.

3-4 July--Meetings with Dr. John Lowe and other FAO personnel.

5-6 July--Local holidays.

8-12 July--Assistance promised by local cooperating scientist does not materialize; prepare travel report.

13-14 July--Visas received; make preparations for collecting at Phuket, Thailand.

15 July--Travel to Phuket.

16-20 July--Severe monsoon rains; mudslides curtail travel and collecting.

21-26 July--Survey for hydrilla sites; collect hydrilla insects.

27 July--Travel to Penang, Malaysia.

28 July--Meetings with Dr. Ivor Caunter, Malaysia University of Science.

29 July--Collect hydrilla and associated insects on Penang Island.

30 July--Collect hydrilla and associated insects in Butterworth vicinity.

31 July--Process samples; pack equipment.

1 August--Travel to Medan, Sumatra.

2-3 August--Survey for hydrilla in Medan vicinity.

4 August--Travel to Lake Toba, Sumatra.

5-10 August--Weather permitting, collect hydrilla insects.

11 August--Travel to Medan, Sumatra.

12 August--Travel to Jakarta.

13 August--Meetings at Embassy.

14-17 August--Collecting in Bogor vicinity.

18 August--Travel to Yogykarta, Java.

19-22 August--Collecting at Jambor and Rawa Pening Lakes.

23 August--Finish processing samples; pack equipment.

24 August--Travel to Jakarta.

25 August--Meetings at Embassy.

26-27 August--Research at Bogor Herbarium.

28 August--Meetings with Dr. Kosterman, Biotrop, and Dr. Somidikarta, University of Indonesia.

29-30 August--Make arrangements for travel to Sulawesi; pack equipment.

31 August--Travel to Ujung Pandang, South Sulawesi.

1 September--Meetings with Drs. Nengah and Barkey at Hasanuddin University.

2 September--Travel to Soppeng, Southwest Sulawesi.

3-5 September--Survey Lake Tempe; collect hydrilla insects in vicinity.

6 September--Travel to Ratnepao, South Sulawesi.

7-9 September--Collecting in Ratnepao vicinity.

10 September--Travel to Ujung Pandang.

11 September--Travel to Jakarta, Java.

12-13 September--Process samples; meeting at US Embassy.

14 September--Travel to Denpasar, Bali.

15 September--Make travel arrangements for Lombok.

16 September--Travel to Mataram, Lombok; survey for hydrilla.

17-20 September--Survey and collect in Lombok.

21 September--Travel to Denpasar, Bali.

22 September--Survey vicinity north of Denpasar.

23-29 September--Annual leave.

30 September--Make arrangements for travel to Australia.

1 October--Travel to Darwin, Australia.

2-8 October--Meeting with I. Miller, J. Gillett; collecting in Darwin and Jabiru vicinities.

9 October--Travel to Cairns, Australia.

10-18 October--Collecting in the Cairns-Daintree-Atherton vicinity.

19 October--Travel to Brisbane, Australia.

20-22 October--Meetings with Drs. K. Harley, D. Sands, Mr. A. Wright, and other Commonwealth Industrial and Scientific Organization personnel; pack equipment for return to United States.

23-24 October--Travel to Fort Lauderdale, Fla.

APPENDIX F: TRAVEL LOG FOR 1983 (24 MAY - 18 OCTOBER)
OVERSEAS HYDRILLA SURVEY

24 May--Depart Miami Airport at 8 a.m.

25 May--Arrive Manila Airport at 9 p.m.; met by Dr. Peter Kenmore; travel to Los Banos (= Los Banjos).

26 May--Meetings with Dr. Kenmore; meetings with Dr. Juan Pancho, Botany Department, University of Philippines at Los Banos (UPLB); drive to Manila with Dr. Kenmore; meetings at US Embassy; make arrangements to obtain visas for countries for which visas were not obtained prior to departure.

27 May--Meetings with Dr. Kenmore and Dr. Paller, UPLB.

28 May--Collect hydrilla at Lake Tadlock with Ray Valesco, entomologist from UPLB; set up Berlese funnels.

29 May--Finish processing previous day's sample.

30 May-2 June--Additional meetings with UPLB faculty. Collect hydrilla at Laguna de Bay. Process samples. Blacklight collecting at Laguna de Bay.

3 June--Drive to Manila. Make travel arrangements for myself and Blas Hernaez, plant collector at UPLB, to travel to the islands of Cebu and Mindanao. Return to Los Banos.

4 June--Make arrangements for transportation to Manila airport. Pack equipment and samples. Store equipment not needed for Mindanao trip.

5 June--Travel to Manila airport. Fly to Cebu Island with Mr. Hernaez. Find accommodations while waiting for the next flight to Mindanao on Tuesday.

6 June--Change to cheaper accommodations. Survey for hydrilla on Cebu.

7 June--Leave Cebu City at 4:30 a.m. for airport. Fly to Iligan on Mindanao with Mr. Hernaez. Make arrangements for transportation to Mindanao State University (MSU) at Marawl. Meet with Dr. Robert McAmis from MSU. Meet with Moctar Matuan, assistant director at the Dansalen Research Center in Marawl. Dansalen personnel will make arrangements for hiring boat on Lake Lanao and will accompany me as interpreters. In the evening, meet with Bob Vore and George McTalls, American Peace Corps volunteers at MSU.

8-9 June--Spend two mornings surveying Lake Lanao. Collect hydrilla. Process samples in afternoon and evenings.

11 June--Finish processing samples. Pack specimens and equipment. Make arrangements for return to Manila.

12 June--Drive to Iligan. Fly to Cebu accompanied by Mr. Hernaez.

13 June--Fly to Manila. Meetings at US Embassy. Take passport to Papua New Guinea Embassy to obtain visa. Take taxi to Los Banos.

14 June--Meetings at UPLB. Discuss best arrangements for collecting at Lake Mindoro.

15 June--Taxi to Manila. Unsuccessful in making travel arrangements to Mindoro Island and then to Lake Mindoro and return.

16-19 June--Heavy monsoon rains, long-delayed beginning. Cancel plans for collecting in southern Luzon.

20 June--Pack equipment. Transfer to Hotel in Manila. Meetings at Embassy.

21 June--Make final arrangements to travel to Sabah (North Borneo). Store equipment not being taken to Sabah.

22 June--Fly to Kota Kinabalu, Sabah. Arrive Kota Kinabalu. Find accommodations; purchase maps and guide book.

23 June--Hire rental car. Attempt (unsuccessfully) to locate government official familiar with aquatic weeds.

24 June--Survey highlands area (Ranau vicinity) west of Kota Kinabalu.

25-26 June--Saturday and Sunday, free time.

27 June--Survey north of Kota Kinabalu (Tuaran vicinity).

28 June--Survey south of Kota Kinabalu (Sipitang vicinity); make flight arrangements to Sandakan.

29 June--Fly to Sandakan. Make arrangements to hire car with English-speaking driver.

30 June--Survey in Sepilok area.

1-2 July--Survey on the Kinabatangan River by boat.

3 July--Free time.

4 July--Survey in Sandakan vicinity.

5 July--Fly back to Kota Kinabalu.

6 July--Fly to Manila. Prepare specimens for shipment.

7 July--Pack equipment. Mail specimens. Depart for Papua New Guinea by plane.

8 July--Arrive in Port Moresby, Papua New Guinea (PNG), after night flight from Manila. Met at airport by Dr. John Ismay, Department of Primary Industry. Meet with Drs. Greg Leach and Paddy Osborne, aquatic botanists at University of Papua New Guinea. Collect hydrilla in Port Moresby.

9 July--Purchase equipment to allow operation of Berlese funnels on local current. Finish processing previous day's sample.

10 July--Survey Sirinumu Dam and Sogeri vicinity with Dr. Ismay. No hydrilla found.

11 July--Begin making arrangements for collecting in other portions of PNG. Collect hydrilla at Port Moresby Botanical Garden.

12 July--Finish processing previous day's sample. Collect hydrilla at campus of University of PNG.

13-14 July--Continue processing samples. Continue with arrangements for extensive travel in PNG.

15 July--Complete processing samples. Make final travel arrangements. Pack equipment.

16 July--Travel by air to Lae. Then travel by rental car to Bulolo and collect hydrilla. Spend next two nights in Wau.

17 July--Process previous day's sample. Return to Bulolo and collect hydrilla at additional site.

18 July--Finish processing samples. Pack equipment. Drive back to Lae.

19 July--Travel to Madang by air. Hire car. Survey Madang vicinity.

20 July--Survey Alexhoffen vicinity. Pack equipment.

21 July--Fly to Wewak. Met by Dr. Phil Thomas, coordinator for the FAO *Salvinia* control project. Travel with Dr. Thomas by car to Angoram. Begin surveying the Sepik River for hydrilla by boat.

22 July--Inspect release area of *Cyrtobagus*, the weevil released to control *Salvinia*. Continue surveying Sepik River. No hydrilla found. Return in evening to Wewak.

23 July--Fly to Mt. Hagen. Hire car and survey for hydrilla in the Mt. Hagen-Baiyer River area.

24 July--Free time.

25 July--Return from Baiyer River to Mt. Hagen, surveying enroute.

26 July--Fly to Mendi. Meet with Jim Dees, Deputy Director of the Southern Highlands Project. Begin making arrangements to travel to Lake Kotubu.

27 July--Assemble camping equipment, buy gasoline, food, and other items required for Lake Kotubu. Fly to Pimaga on chartered flight, but unable to land due to inclement weather. Luckily, we are eventually able to return to Mendi.

28 July--Take charter flight to Pimaga. Meet with Francis Debonai, Officer-in-Charge of the village. Make arrangements for three motorcycles to transport me and my equipment the 20 km to Lake Kotubu. Spend afternoon collecting hydrilla on Lake Kotubu. Return to Pimaga and spend night.

30-31 July--Process samples collected at Lake Kotubu.

1 August--Fly back to Port Moresby. Begin packing specimens and equipment.

2 August--Send specimens back to United States. Present seminar at University of PNG. Finish packing.

3 August--Travel by air to Australia. Arrive Cairns, northern Queensland Australia. Arrange rental car, lodging, etc.

4 August--Survey Cairns vicinity. Collect hydrilla at Centennary Gardens. Set up Berlese funnels.

5 August--Complete processing of previous day's sample. Find *Parapoynx* larvae. Collect additional hydrilla from Centennary Gardens.

6 August--Process previous day's sample. Collect hydrilla at Freshwater River.

7 August--Finish processing previous day's samples. Begin packing equipment.

8 August--Complete packing samples and equipment. Travel (by air) to Darwin, Northern Territory.

9 August--Meetings with John Gillett, Department of Primary Production. Make arrangements and obtain permission to collect at Kakadu National Park, 300 km east of Darwin.

10 August--Travel by car with J. Gillett to Kakadu National Park. Inspect *Mimosa* infestations enroute. Collect at Yellowwater Billabong with Peter Wellings, Park Ranger. Spend night at Cooinda. Blacklight collecting at Yellowwater River.

11 August--Return to Darwin. Set up Berlese funnels.

12-13 August--Continue processing material collected at Yellowwater Billabong.

14 August--Free time. Hire car in evening for a return trip to Kakadu National Park.

15 August--Make arrangements with Kakadu National Park for additional collecting. Travel to Kakadu National Park. Collect hydrilla at Yellowwater Billabong.

16 August--Return to Darwin. Set up Berlese samples.

17-18 August--Continue processing collections. Begin packing equipment.

19 August--Pack specimens and equipment. Mail specimens to United States. Travel to Indonesia by air. Arrive Denpasar. Arrange lodgings, etc.

20-21 August--Free time.

22 August-1 September--Prepare report on first 3-month's travel; other administration and correspondence.

1 September--Collect hydrilla and associated insects near Denpasar; blacklight collecting.

2-4 September--Set up Berlese and finish processing previous day's sample.

5 September--Pack specimens and equipment; make travel arrangements to Penang.

6 September--Travel to Penang, Malaysia. Arrive Penang, Malaysia.

7 September--Meetings at Malaysia University of Science; collect hydrilla insects on Penang Island; blacklight collecting at night.

8-10 September--Complete processing previous day's samples; heavy monsoon rains prevent additional collecting.

11 September--Meetings with Dr. Ivor Caunter.

12 September--Depart for Rangoon, Burma. Arrive Rangoon, Burma.

13 September--Meetings with US Embassy officials; meetings with Dr. Crowe, FAO.

14 September--Collect hydrilla in Rangoon vicinity.

15 September--Complete processing previous day's sample.

16 September--Travel to Mandalay; collect hydrilla in Mandalay moat.

17 September--Complete processing previous day's samples.

18 September--Survey for hydrilla in Maymyo vicinity, 70 km from Mandalay.

19 September--Additional collecting at Mandalay moat.

20 September--Return to Rangoon.

21 September--Collect hydrilla insects in Rangoon vicinity.

22 September--Complete processing previous day's samples; meetings at US Embassy.

23 September--Travel to Bangkok.

24 September--Meetings with Drs. Lowe and Kenmore, FAO.

25 September--Travel to Delhi, India.

26 September--Arrive New Delhi; meetings with Dr. J. Smith and other FERRO personnel.

27 September--Complete financial and travel arrangements for research at Dal Lake.

28 September--Travel to Srinagar, Kashmir (Dal Lake).

29 September-1 October--Recover from Shigellosis dysentery.

2-11 October--Collect hydrilla insects at Dal Lake.

12 October--Complete sampling, pack specimens and equipment.

13 October--Return to Delhi; submit expense account.

14 October--Local holiday - free time.

15 October--Free time.

16 October--Meetings with Dr. J. Smith and Dr. T. Sankaran.

17 October--Leave Delhi, hand-carrying *Bagous* larvae from Dal Lake.

18 October--Arrive Fort Lauderdale.

APPENDIX G. ASIA AND AUSTRALIA RAKE AND BERLESE COLLECTIONS OF HYDRILLA VERTICILLATA INVERTEBRATES (1981 - 1983)

| COLL_NO | SAMPLES | SMP_METH | DATE | SITE | LOCATION | STATE | COUNTRY |
|---|---|---|---|---|---|---|---|
| NTR82201 | 1 | RAKE | 04OCT1982 | BERRY SPRINGS | 15 KM SW OF NOONAMAH | NORTHERN TERRITORY | AUSTRALIA |
| NTR82202 | 1 | RAKE | 06OCT1982 | ISLIND BILLABONG | 15 KM N OF JABIRU | NORTHERN TERRITORY | AUSTRALIA |
| NTR82203 | 1 | RAKE | 07OCT1982 | YELLOWWATER BILLABONG | 55 KM SW OF JABIRU | NORTHERN TERRITORY | AUSTRALIA |
| NTR83201 | 1 | RAKE | 11AUG1983 | YELLOWWATER BILLABONG | 55 KM SW OF JABIRU | NORTHERN TERRITORY | AUSTRALIA |
| NTR83202 | 1 | RAKE | 15AUG1983 | YELLOWWATER BILLABONG | 55 KM SW OF JABIRU | NORTHERN TERRITORY | AUSTRALIA |
| NTR832Z1 | 3 | BRLESE | 11AUG1983 | YELLOWWATER BILLABONG | 55 KM SW OF JABIRU | NORTHERN TERRITORY | AUSTRALIA |
| NTR832Z2 | 3 | BRLESE | 15AUG1983 | YELLOWWATER BILLABONG | 55 KM SW OF JABIRU | NORTHERN TERRITORY | AUSTRALIA |
| QLD82201 | 1 | RAKE | 12OCT1982 | DAINTREE RIVER | 4 KM E OF DAINTREE | QUEENSLAND | AUSTRALIA |
| QLD82202 | 1 | RAKE | 15OCT1982 | FRESHWATER CREEK | 50 M ABOVE FRESHWATER SWIM AREA | QUEENSLAND | AUSTRALIA |
| QLD82203 | 1 | RAKE | 18OCT1982 | BARRON RIVER | 100 M BELOW TINNAROO DAM SPILLWAY | QUEENSLAND | AUSTRALIA |
| QLD82204 | 1 | RAKE | 20OCT1982 | CENTENARY LAKES | FLECKER BOTANICAL GARDENS, CAIRNS | QUEENSLAND | AUSTRALIA |
| QLD83201 | 1 | RAKE | 04AUG1983 | CENTENARY LAKES | FLECKER BOTANICAL GARDENS, CAIRNS | QUEENSLAND | AUSTRALIA |
| QLD83202 | 1 | RAKE | 06AUG1983 | FRESHWATER CREEK | 50 M ABOVE FRESHWATER SWIM AREA | QUEENSLAND | AUSTRALIA |
| QLD832Z1 | 2 | BRLESE | 04AUG1983 | CENTENARY LAKES | FLECKER BOTANICAL GARDENS, CAIRNS | QUEENSLAND | AUSTRALIA |
| QLD832Z2 | 1 | BRLESE | 06AUG1983 | FRESHWATER CREEK | 50 M ABOVE FRESHWATER SWIM AREA | QUEENSLAND | AUSTRALIA |
| BUR81201 | 1 | RAKE | 10JUL1981 | INYA LAKE | WASHINGTON PARK,RANGOON | RANGOON DIVISION | BURMA |
| BUR81202 | 1 | RAKE | 14JUL1981 | MANDALAY MOAT | NEAR SW CORNER OF POND | MANDALAY DIVISION | BURMA |
| BUR82201 | 1 | RAKE | 21JUN1982 | ROADSIDE DITCH | SEDAWGE DAM WORKERS COMPOUND | MANDALAY DIVISION | BURMA |
| BUR82202 | 1 | RAKE | 21JUN1982 | MANDALAY MOAT | FORT MANDALAY | MANDALAY DIVISION | BURMA |
| BUR82203 | 1 | RAKE | 25JUN1982 | INLE LAKE | 2 KM W OF MOUNGTAUK | SHAN STATE | BURMA |
| BUR82204 | 1 | RAKE | 26JUN1982 | INLE MARSH | 0.5 MI N OF SHWEVANPYE | SHAN STATE | BURMA |
| BUR82205 | 1 | RAKE | 28JUN1982 | KANDAWMEIK POND | SHWEDAGON PAGODA, RANGOON | RANGOON DIVISION | BURMA |
| BUR82206 | 1 | RAKE | 30JUN1982 | RANGOON LAKE | LAKE INYA, SOUTH END | RANGOON DIVISION | BURMA |
| BUR83201 | 1 | RAKE | 14SEP1983 | KANDOME GARDENS POND | RANGOON | RANGOON DIVISION | BURMA |
| BUR83202 | 1 | RAKE | 18SEP1983 | MANDALAY MOAT | FORT MANDALAY | MANDALAY DIVISION | BURMA |
| BUR83203 | 1 | RAKE | 22SEP1983 | INYA LAKE | WASHINGTON PARK,RANGOON | RANGOON DIVISION | BURMA |
| BUR832Z1 | 1 | BRLESE | 14SEP1983 | KANDOME GARDENS POND | RANGOON | RANGOON DIVISION | BURMA |
| BUR832Z2 | 1 | BRLESE | 18SEP1983 | MANDALAY MOAT | FORT MANDALAY | MANDALAY DIVISION | BURMA |
| BUR832Z3 | 1 | BRLESE | 22SEP1983 | INYA LAKE | WASHINGTON PARK,RANGOON | RANGOON DIVISION | BURMA |
| KAR81201 | 1 | RAKE | 01JUL1981 | ARKAVARTI STREAM | 19.5 KM SE OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR81202 | 1 | RAKE | 01JUL1981 | KULUNANAHALLI POND | 30 KM S OF TUMKUR | KARNATAKA STATE | INDIA |
| KAR81203 | 1 | RAKE | 01JUL1981 | BARAGENAHALLI POND | BARAGENAHALLI VILLAGE | KARNATAKA STATE | INDIA |
| KAR81204 | 1 | RAKE | 03JUL1981 | UMMULUGODU POND | UMMULUGODU VILLAGE | KARNATAKA STATE | INDIA |
| KAR81205 | 1 | RAKE | 03JUL1981 | SESHAGIRIHALLI POND | SESHAGIRIHALLI VILLAGE | KARNATAKA STATE | INDIA |
| KAR81206 | 1 | RAKE | 03JUL1981 | DASAPPADODDI POND | 35.5 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82201 | 1 | RAKE | 11MAY1982 | OSUKKRE POND | 23.1 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82202 | 1 | RAKE | 07MAY1982 | DASAPPADODDI POND | 35.5 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82203 | 1 | BRLESE | 11MAY1982 | OSUKKRE POND | 23.1 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82204 | 1 | BRLESE | 11MAY1982 | DASAPPADODDI POND | 35.5 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82205 | 1 | RAKE | 20MAY1982 | MEDAHALLI WELL | 15 KM E OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82206 | 1 | RAKE | 20MAY1982 | HOSKOTTE KERE | PADDY FIELD 35 KM E OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82207 | 1 | BRLESE | 24MAY1982 | DASAPPADODDI POND | 35.5 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAS83201 | 1 | RAKE | 29SEP1983 | DAL LAKE | 5 KM N OF SRINAGAR | KASHMIR STATE | INDIA |
| KAS83202 | 1 | RAKE | 03OCT1983 | DAL LAKE | 5 KM N OF SRINAGAR | KASHMIR STATE | INDIA |
| KAS83203 | 1 | RAKE | 05OCT1983 | DAL LAKE CANAL | SRINAGAR | KASHMIR STATE | INDIA |
| KAS832Z1 | 1 | BRLESE | 29SEP1983 | DAL LAKE | 5 KM N OF SRINAGAR | KASHMIR STATE | INDIA |
| KAS832Z3 | 1 | BRLESE | 05OCT1983 | DAL LAKE CANAL | SRINAGAR | KASHMIR STATE | INDIA |
| KAS832Z4 | 1 | BRLESE | 10OCT1983 | DAL LAKE | 5 KM N OF SRINAGAR | KASHMIR STATE | INDIA |

APPENDIX G CONTINUED.

| COLL_NO | SAMPLES | SMP_METH | DATE | SITE | LOCATION | STATE | COUNTRY |
|---|---|---|---|---|---|---|---|
| BAL83201 | 1 | RAKE | 01SEP1983 | KUTA CANAL | 5 KM NE OF DENPASAR | BALI | INDONESIA |
| BAL83221 | 2 | BRLESE | 01SEP1983 | KUTA CANAL | 5 KM NE OF DENPASAR | BALI | INDONESIA |
| JAV81201 | 1 | RAKE | 11AUG1981 | CIBINONG POND | 10 KM N OF BOGOR | WEST JAVA | INDONESIA |
| JAV81202 | 1 | RAKE | 19AUG1981 | CURUG RESERVOIR | NORTH END | WEST JAVA | INDONESIA |
| JAV81203 | 1 | RAKE | 27AUG1981 | RAWA PENING RESERVOIR | NEAR TUNTANG VILLAGE | CENTRAL JAVA | INDONESIA |
| JAV81204 | 1 | RAKE | 28AUG1981 | JAMBOR LAKE | 10 KM S OF KLATEN | CENTRAL JAVA | INDONESIA |
| JAV81205 | 1 | RAKE | 01SEP1981 | SENGGRENG LAKE | 25 KM S OF MALANG | EAST JAVA | INDONESIA |
| JAV81206 | 1 | RAKE | 01SEP1981 | IRRIGATION CANAL | 3 KM N OF KEDIRI | EAST JAVA | INDONESIA |
| LOM82201 | 1 | RAKE | 15SEP1982 | NARMADA TEMPLE POOL | 5 KM E OF MATARAM | LOMBOK | INDONESIA |
| SUL82201 | 1 | RAKE | 03SEP1982 | LAKE LAMPULUNG | 5 KM NE OF SENGKANG | SE SULAWESI | INDONESIA |
| SUL82202 | 1 | RAKE | 08SEP1982 | MAKALE LAKE | 17 KM S OF RATNEPAO | SE SULAWESI | INDONESIA |
| SUM81201 | 1 | RAKE | 07SEP1981 | CANAL BBGK1 | 1 KM FROM LAKE SAPPAR | LUMPONG | INDONESIA |
| SUM81202 | 1 | RAKE | 11SEP1981 | LAKE TOBA | E SHORE OF SAMOSIR ISLAND | NORTH SUMATRA | INDONESIA |
| SUM81203 | 1 | RAKE | 14SEP1981 | LAKE TOBA | SE END OF SAMOSIR ISLAND | NORTH SUMATRA | INDONESIA |
| SUM81204 | 1 | RAKE | 15SEP1981 | IRRIGATION CANAL | KUTABARU VILLAGE | NORTH SUMATRA | INDONESIA |
| SUM81205 | 1 | RAKE | 16SEP1981 | TANJUNG KILILING POND | 50 KM SW OF MEDAN | NORTH SUMATRA | INDONESIA |
| PEN81201 | 1 | RAKE | 31JUL1981 | IRRIGATION CANAL | BALIK PULAU VILLAGE | PENANG STATE | MALAYSIA |
| PEN82201 | 1 | RAKE | 29JUL1982 | SMALL STREAM | 0.25 KM W OF BAYAN LEPAS | PENANG STATE | MALAYSIA |
| PEN82202 | 1 | RAKE | 07APR1982 | IRRIGATION CANAL | BALIK PULAU VILLAGE | PENANG STATE | MALAYSIA |
| PEN82203 | 4 | RAKE | 20MAY1982 | IRRIGATION CANAL | BALIK PULAU VILLAGE | PENANG STATE | MALAYSIA |
| PEN82204 | 1 | RAKE | 30MAY1982 | IRRIGATION CANAL | BALIK PULAU VILLAGE | PENANG STATE | MALAYSIA |
| PEN82205 | 1 | RAKE | 05JUN1982 | IRRIGATION CANAL | BALIK PULAU VILLAGE | PENANG STATE | MALAYSIA |
| PEN83201 | 1 | RAKE | 07SEP1983 | IRRIGATION CANAL | BALIK PULAU VILLAGE | PENANG STATE | MALAYSIA |
| PEN83221 | 1 | BRLESE | 07SEP1983 | IRRIGATION CANAL | BALIK PULAU VILLAGE | PENANG STATE | MALAYSIA |
| PRK82201 | 1 | RAKE | 30JUL1982 | IRRIGATION CANAL | 3 KM N OF KUALA KURAY | PERAK STATE | MALAYSIA |
| PRK82202 | 1 | RAKE | 20APR1982 | IRRIGATION CANAL | PARIT HAJI LABIS | PERAK STATE | MALAYSIA |
| PRK82203 | 1 | RAKE | 20APR1982 | IRRIGATION CANAL | SUNGAI BURUNG BATU II | PERAK STATE | MALAYSIA |
| PRK82204 | 2 | RAKE | 20APR1982 | IRRIGATION CANAL | KAMPUNG BANAN TIANG | PERAK STATE | MALAYSIA |
| PRK82205 | 1 | RAKE | 20APR1982 | IRRIGATION CANAL | KAMPUNG TOK ADAM | PERAK STATE | MALAYSIA |
| PRK82206 | 2 | RAKE | 23JUN1982 | CHENDEROH DAM | SITE B | PERAK STATE | MALAYSIA |
| PRK82207 | 1 | RAKE | 24JUN1982 | CHENDEROH DAM | SITE A | PERAK STATE | MALAYSIA |
| PRK82208 | 2 | RAKE | 24JUN1982 | CHENDEROH DAM | SITE B | PERAK STATE | MALAYSIA |
| PRK82209 | 1 | RAKE | 26JUN1982 | CHENDEROH DAM | SITE C | PERAK STATE | MALAYSIA |
| PRK82210 | 3 | RAKE | 28JUN1982 | CHENDEROH DAM | SITE A | PERAK STATE | MALAYSIA |
| PRK82211 | 3 | RAKE | 28JUN1982 | CHENDEROH DAM | SITE C | PERAK STATE | MALAYSIA |
| PRK82212 | 1 | RAKE | 29JUN1982 | CHENDEROH DAM | SITE A | PERAK STATE | MALAYSIA |
| PRK83201 | 1 | RAKE | . SEP1983 | STREAM | TELUK KUMBAR VILLAGE | PERAK STATE | MALAYSIA |
| PRK83202 | 2 | RAKE | . NOV1983 | LAKE | KAMPUNG BIONG VILLAGE | PERAK STATE | MALAYSIA |
| PRK83203 | 2 | RAKE | . NOV1983 | POND | SUNGAI SIPUT VILLAGE | PERAK STATE | MALAYSIA |
| PAP83201 | 1 | RAKE | 08JUL1983 | SMALL STREAM | N END OF PORT MORESBY AIRPORT | CENTRAL PROVINCE | PAPUA NEW GUINEA |
| PAP83202 | 1 | RAKE | 11JUL1983 | SMALL POOL | UNIVERSITY OF PORT MORESBY | CENTRAL PROVINCE | PAPUA NEW GUINEA |
| PAP83203 | 1 | RAKE | 12JUL1983 | SMALL DITCH | UNIVERSITY OF PORT MORESBY | CENTRAL PROVINCE | PAPUA NEW GUINEA |
| PAP83204 | 1 | RAKE | 16JUL1983 | SMALL BORROW PIT A | BULOLO VILLAGE | MOROBE PROVINCE | PAPUA NEW GUINEA |
| PAP83205 | 1 | RAKE | 17JUL1983 | SMALL BORROW PIT B | BULOLO VILLAGE | MOROBE PROVINCE | PAPUA NEW GUINEA |
| PAP83206 | 1 | RAKE | 28JUL1983 | KOTUBU LAKE | KAIMARI-TAGA, MENDI VILLAGE | S.HIGHLANDS PROV. | PAPUA NEW GUINEA |
| PAP83221 | 1 | BRLESE | 08JUL1983 | SMALL STREAM | N END OF PORT MORESBY AIRPORT | CENTRAL PROVINCE | PAPUA NEW GUINEA |
| PAP83222 | 1 | BRLESE | 11JUL1983 | SMALL POOL | UNIVERSITY OF PORT MORESBY | CENTRAL PROVINCE | PAPUA NEW GUINEA |
| PAP83223 | 1 | BRLESE | 11JUL1983 | SMALL DITCH | UNIVERSITY OF PORT MORESBY | CENTRAL PROVINCE | PAPUA NEW GUINEA |
| PAP83224 | 1 | BRLESE | 16JUL1983 | SMALL BORROW PIT A | BULOLO VILLAGE | MOROBE PROVINCE | PAPUA NEW GUINEA |
| PAP83225 | 1 | BRLESE | 17JUL1983 | SMALL BORROW PIT B | BULOLO VILLAGE | MOROBE PROVINCE | PAPUA NEW GUINEA |
| PAP83226 | 1 | BRLESE | 28JUL1983 | KOTUBU LAKE | KAIMARI-TAGA, MENDI VILLAGE | S.HIGHLANDS PROV. | PAPUA NEW GUINEA |

APPENDIX G CONTINUED.

| COLL_NO | SAMPLES | SMP_METH | DATE | SITE | LOCATION | STATE | COUNTRY |
|---|---|---|---|---|---|---|---|
| LUZ83201 | 1 | RAKE | 29MAY1983 | LAKE TADLAK,LUZON | 5 KM W LOS BANOS | LAGUNA PROVINCE | PHILIPPINES |
| LUZ83202 | 1 | RAKE | 31MAY1983 | LAGUNA DE BAY,LUZON | LOS BANOS | LAGUNA PROVINCE | PHILIPPINES |
| LUZ83221 | 2 | BRLESE | 29MAY1983 | LAKE TADLAK,LUZON | 5 KM W LOS BANOS | LAGUNA PROVINCE | PHILIPPINES |
| LUZ83222 | 2 | BRLESE | 31MAY1983 | LAGUNA DE BAY,LUZON | LOS BANOS | LAGUNA PROVINCE | PHILIPPINES |
| MDN83201 | 1 | RAKE | 08JUN1983 | LAKE LANAO,MINDANAO | N END AT BACOLOD CHICA | LANAO DEL SUR PROV | PHILIPPINES |
| MDN83202 | 1 | RAKE | 09JUN1983 | LAKE LANAO,MINDANAO | N END AT PAGALAMATAN VILLAGE | LANAO DEL SUR PROV | PHILIPPINES |
| MDN83221 | 1 | BRLESE | 08JUN1983 | LAKE LANAO,MINDANAO | NW END AT KIALDEN VILLAGE | LANAO DEL SUR PROV | PHILIPPINES |
| MDN83222 | 1 | BRLESE | 08JUN1983 | LAKE LANAO,MINDANAO | N END AT BACOLOD CHICA VILLAGE | LANAO DEL SUR PROV | PHILIPPINES |
| MDN83223 | 1 | BRLESE | 09JUN1983 | LAKE LANAO,MINDANAO | N END AT PAGALAMATAN VILLAGE | LANAO DEL SUR PROV | PHILIPPINES |
| LAN82201 | 1 | RAKE | 04JUN1982 | SMALL STREAM | BORALASGUMUWA,6 MI S OF COLOMBO | WESTERN PROVINCE | SRI LANKA |
| LAN82202 | 1 | RAKE | 06JUN1982 | SELLANKANDAL POND | 6 KM E OF PUTTALAM | NORTHWESTERN PROV. | SRI LANKA |
| LAN82203 | 1 | RAKE | 08JUN1982 | RAJA PASEGAMA RES. | 13 MI S OF ANDRAPHURA | NORTH CENTRAL PROV | SRI LANKA |
| LAN82204 | 1 | RAKE | 08JUN1982 | MAHADIULWEWA RES. | 22 MI W OF TRINCOMALEE | EASTERN PROVINCE | SRI LANKA |
| LAN82205 | 1 | RAKE | 14JUN1982 | PERADENIYA POND | ROYAL BOTANICAL GARDENS | CENTRAL PROVINCE | SRI LANKA |
| PHK82201 | 1 | RAKE | 22JUL1982 | ROADSIDE POND | 7 KM N OF PHUKET | PHUKET STATE | THAILAND |
| PHK82202 | 1 | RAKE | 23JUL1982 | IRRIGATION POND | CHALONG VILLAGE,9.5 KM S OF PHUKET | PHUKET STATE | THAILAND |

APPENDIX H. WATER QUALITY DATA AT HYDRILLA SITES IN ASIA AND AUSTRALIA (1981 - 1983)

| COUNTRY | COLLECTION NUMBER | WATER DEPTH M | WATER TEMPERATURE °C | SALINITY | CONDUCTIVITY | SECCHI DISK TRANSPARENCY | PH |
|---|---|---|---|---|---|---|---|
| AUSTRALIA | NTR82201 | . | 31.0 | 0.0 | 420 | . | . |
| AUSTRALIA | NTR82202 | 1.0 | 28.5 | 0.0 | 35 | 1.0 | . |
| AUSTRALIA | NTR82203 | 0.9 | 29.5 | 0.0 | 75 | 0.35 | . |
| AUSTRALIA | QLD82201 | 0.5 | 28.0 | 0.0 | 550 | . | . |
| AUSTRALIA | QLD82202 | 0.4 | 26.0 | 0.0 | 65 | . | . |
| AUSTRALIA | QLD82203 | 0.4 | 18.0 | 0.0 | 50 | . | . |
| AUSTRALIA | QLD82204 | 0.45 | 23.5 | 0.0 | 115 | . | . |
| AUSTRALIA | NTR83201 | 1.2 | 30.0 | 0.0 | 130 | 1.2 | 5.5 |
| AUSTRALIA | NTR83202 | 1.4 | 25.5 | 0.0 | 137 | 1.3 | 5.0 |
| AUSTRALIA | QLD83201 | 0.4 | 18.0 | 0.0 | 110 | . | 5.0 |
| AUSTRALIA | QLD83202 | 0.8 | 22.3 | 0.0 | 110 | . | 5.0 |
| BURMA | BUR81201 | 0.8 | 25.0 | 0.2 | 260 | . | . |
| BURMA | BUR81202 | 0.5 | 30.5 | 0.0 | 165 | . | . |
| BURMA | BUR82201 | 0.3 | 30.0 | 0.0 | 465 | . | . |
| BURMA | BUR82202 | 0.4 | 32.0 | 0.0 | 160 | . | . |
| BURMA | BUR82203 | 3.0 | 27.0 | 0.0 | 238 | . | . |
| BURMA | BUR82204 | 1.0 | 24.5 | 0.0 | 370 | . | . |
| BURMA | BUR82205 | 1.5 | 27.0 | 0.0 | 165 | 0.5 | . |
| BURMA | BUR82206 | 1.0 | 28.0 | 0.0 | 85 | 0.5 | . |
| BURMA | BUR83201 | 1.2 | 29.0 | 0.0 | 325 | 1.0 | 5.5 |
| BURMA | BUR83202 | 0.6 | 31.0 | 0.0 | 275 | 1.0 | 7.0 |
| BURMA | BUR83203 | 0.5 | . | 0.0 | 125 | . | 5.0 |
| INDIA | KAR81201 | 0.3 | 24.0 | 0.0 | 330 | . | . |
| INDIA | KAR81202 | 0.2 | 26.5 | 0.3 | 950 | . | . |
| INDIA | KAR81203 | . | 25.0 | 0.0 | 145 | . | . |
| INDIA | KAR81204 | . | 25.5 | 0.0 | 620 | . | . |
| INDIA | KAR81205 | 0.2 | 25.0 | 0.0 | 320 | . | . |
| INDIA | KAR81206 | 0.25 | 23.5 | 0.0 | 170 | . | . |
| INDIA | KAR82201 | 0.4 | 26.0 | 0.0 | 415 | . | . |
| INDIA | KAR82202 | . | 27.0 | 0.0 | 225 | . | . |
| INDIA | KAR82205 | 0.3 | 28.0 | 2.5 | 500 | . | . |
| INDIA | KAR82206 | 0.3 | 29.5 | 0.0 | 360 | . | . |
| INDIA | KAS83201 | 0.6 | . | 0.0 | 135 | . | 6.0 |
| INDIA | KAS83202 | 1.1 | . | 0.0 | 117 | . | 6.0 |
| INDIA | KAS83203 | 1.8 | . | 0.0 | 135 | . | . |
| INDONESIA | JAV81201 | 1.2 | 26.0 | 0.0 | 70 | . | . |
| INDONESIA | JAV81202 | 0.9 | 26.5 | 0.0 | 198 | . | . |
| INDONESIA | JAV81203 | 1.5 | 28.0 | 0.0 | 180 | . | . |
| INDONESIA | JAV81204 | 1.2 | 28.5 | 0.0 | 320 | . | . |
| INDONESIA | JAV81205 | . | 29.0 | 0.0 | 335 | . | . |
| INDONESIA | JAV81206 | 0.5 | 29.5 | 0.4 | 490 | . | . |
| INDONESIA | SUM81201 | 2.0 | 28.5 | 0.0 | 100 | 1.9 | . |
| INDONESIA | SUM81202 | 1.0 | 24.5 | 0.0 | 340 | . | . |
| INDONESIA | SUM81203 | 2.3 | 24.5 | 0.0 | 150 | . | . |
| INDONESIA | SUM81204 | 1.25 | 25.0 | 0.0 | 140 | . | . |
| INDONESIA | SUM81205 | 0.7 | 25.0 | 0.0 | 90 | . | . |
| INDONESIA | LOM82201 | 1.0 | 25.8 | 0.0 | 145 | . | . |
| INDONESIA | SUL82201 | 1.0 | 27.5 | 0.0 | 225 | 0.9 | . |
| INDONESIA | SUL82202 | 0.5 | 26.0 | 0.0 | 400 | . | . |
| INDONESIA | BAL83201 | 0.4 | 31.0 | 0.0 | 650 | . | 6.9 |
| MALAYSIA | PEN81201 | 0.5 | 25.5 | 0.0 | 65 | . | . |
| MALAYSIA | PEN82201 | 0.5 | 26.0 | 0.0 | 55 | . | . |
| MALAYSIA | PEN82202 | . | . | . | 63 | 0.5 | 6.2 |
| MALAYSIA | PRK82201 | 0.3 | 29.0 | 0.0 | 600 | . | . |
| MALAYSIA | PRK82202 | . | . | . | 47 | 0.4 | 5.8 |
| MALAYSIA | PRK82203 | . | . | . | 900 | 0.2 | 6.6 |
| MALAYSIA | PRK82204 | . | . | . | 250 | 0.2 | 6.2 |
| MALAYSIA | PRK82205 | . | . | . | 225 | 0.4 | 6.2 |
| MALAYSIA | PRK82206 | . | . | . | 57 | 1.0 | 6.6 |
| MALAYSIA | PRK82207 | . | . | . | 70 | 0.7 | 7.5 |
| MALAYSIA | PRK82209 | . | . | . | 61 | 1.0 | 7.7 |
| MALAYSIA | PEN83201 | 0.35 | 31.0 | 0.0 | 197 | . | 5.2 |
| MALAYSIA | PRK83201 | . | 26.5 | . | 50 | . | . |
| MALAYSIA | PRK83202 | . | 30.0 | . | 50 | . | . |
| MALAYSIA | PRK83203 | . | 29.0 | . | 180 | . | . |
| NEW GUINEA | PAP83201 | 1.6 | 31.5 | . | 960 | . | 7.2 |
| NEW GUINEA | PAP83202 | 0.3 | 31.5 | 0.0 | 220 | . | 6.4 |
| NEW GUINEA | PAP83203 | 0.25 | 31.0 | 0.0 | 225 | . | 7.4 |
| NEW GUINEA | PAP83204 | 2.0 | 33.0 | 0.0 | 410 | 1.0 | 7.0 |
| NEW GUINEA | PAP83205 | 2.0 | 31.0 | 0.0 | 325 | 1.0 | 7.0 |
| NEW GUINEA | PAP83206 | 2.3 | 24.5 | 0.0 | 750 | . | 6.8 |
| PHILIPPINES | LUZ83201 | 0.25 | 33.0 | 0.5 | 1250 | 1.1 | 7.6 |
| PHILIPPINES | LUZ83202 | . | . | . | . | . | . |
| PHILIPPINES | MDN83201 | 2.0 | 28.25 | 0.0 | 127 | . | 6.8 |
| PHILIPPINES | MDN83202 | 2.5 | 28.0 | 0.0 | 130 | . | 6.9 |
| SRI LANKA | LAN82201 | 0.3 | 28.0 | 0.0 | 220 | . | . |
| SRI LANKA | LAN82202 | 1.0 | 28.5 | 0.0 | 225 | 0.2 | . |
| SRI LANKA | LAN82203 | 0.25 | 26.0 | 0.0 | 700 | 0.35 | . |
| SRI LANKA | LAN82204 | 0.5 | 25.5 | 0.0 | 345 | . | . |
| SRI LANKA | LAN82205 | 0.3 | 27.5 | 0.0 | 40 | . | . |
| THAILAND | FHK82201 | 1.5 | 28.0 | 0.0 | 400 | . | . |
| THAILAND | FHK82202 | 1.0 | 28.0 | 0.0 | 160 | . | . |

APPENDIX I. ASIA, AFRICA, AND AUSTRALIA SITES OF ULTRAVIOLET LIGHT COLLECTIONS OF AQUATIC INSECTS (1982 - 1983).

| COLL_NO | DATE | SITE | LOCATION | STATE | COUNTRY |
|---|---|---|---|---|---|
| NTR82BL1 | 04OCT1982 | BERRY SPRINGS | 15 KM SW OF NOONAMAH | NORTHERN TERRITORY | AUSTRALIA |
| NTR82BL2 | 04OCT1982 | FOGG DAM | 15 KM NE OF HUMPTY DOO | NORTHERN TERRITORY | AUSTRALIA |
| NTR82BL3 | 06OCT1982 | YELLOWWATER BILLABONG | 55 KM SW OF JABIRU | NORTHERN TERRITORY | AUSTRALIA |
| NTR82BL4 | 07OCT1982 | ISLIND BILLABONG | 15 KM N OF JABIRU | NORTHERN TERRITORY | AUSTRALIA |
| NTR83BL1 | 11AUG1983 | YELLOWWATER BILLABONG | 55 KM SW OF JABIRU | NORTHERN TERRITORY | AUSTRALIA |
| QLD82BL1 | 14OCT1982 | FRESHWATER CREEK | 50 M ABOVE FRESHWATER SWIM AREA | QUEENSLAND | AUSTRALIA |
| BUR82BL1 | 22JUN1982 | MANDALAY MOAT | FORT MANDALAY | MANDALAY DIVISION | BURMA |
| BUR82BL2 | 25JUN1982 | INLE LAKE MARSH | 5 KM N OF YAUNGHWE | SHAN STATE | BURMA |
| KAR82BL1 | 17MAY1982 | DASAPPADODDI POND | 35.5 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82BL2 | 21MAY1982 | MEDAHALLI WELL | 15 KM E OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82BL3 | 24MAY1982 | DASAPPADODDI POND | 35.5 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82BL4 | 28MAY1982 | DASAPPADODDI POND | 35.5 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAS83BL1 | 28SEP1983 | DAL LAKE | 5 KM N OF SRINAGAR | KASHMIR STATE | INDIA |
| KAS83BL2 | 29SEP1983 | NAGIN LAKE | SRINAGAR | KASHMIR STATE | INDIA |
| KAS83BL3 | 05OCT1983 | DAL LAKE | 5 KM N OF SRINAGAR | KASHMIR STATE | INDIA |
| BAL83BL1 | 01SEP1983 | KUTA CANAL | 5 KM NE OF DENPASAR | BALI | INDONESIA |
| JAV82BL1 | 17AUG1982 | CIBINONG POND | 10 KM N OF BOGOR | WEST JAVA | INDONESIA |
| JAV82BL2 | 18AUG1982 | JAMBOR LAKE | 10 KM S OF KLATEN | CENTRAL JAVA | INDONESIA |
| JAV82BL3 | 21AUG1982 | RAWA PENING RESERVOIR | NEAR TUNTANG VILLAGE | CENTRAL JAVA | INDONESIA |
| LOM82BL1 | 16SEP1982 | NARMADA TEMPLE POOL | 5 KM E OF MATARAM | LOMBOK | INDONESIA |
| SUL82BL1 | 03SEP1982 | LAKE LAMPULUNG | 5 KM NE OF SENGKANG | SE SULAWESI | INDONESIA |
| SUM82BL1 | 06AUG1982 | LAKE TOBA | TUK-TUK VILLAGE, 8 KM WSW OF PRAPAT | NORTH SUMATRA | INDONESIA |
| SUM82BL2 | 07AUG1982 | LAKE TOBA | TUK-TUK VILLAGE, 8 KM WSW OF PRAPAT | NORTH SUMATRA | INDONESIA |
| SUM82BL3 | 08AUG1982 | LAKE TOBA | TUK-TUK VILLAGE, 8 KM WSW OF PRAPAT | NORTH SUMATRA | INDONESIA |
| KEN82BL1 | 26APR1982 | LAKE VICTORIA | IMPALA PARK, KIUSA VILLAGE | NYANZA PROVINCE | KENYA |
| PEN83BL1 | 07SEP1983 | IRRIGATION CANAL | BALIK PULAU VILLAGE | PENANG STATE | MALAYSIA |
| PAP83BL1 | 24JUL1983 | BAIYER RIVER | BAIYER RIVER SANCTUARY | W.HIGHLANDS PROV. | PAPUA NEW GUINEA |
| LUZ83BL1 | 31MAY1983 | LAGUNA DE BAY,LUZON | LOS BANOS | LAGUNA PROVINCE | PHILIPPINES |
| PHK82BL1 | 22JUL1982 | IRRIGATION POND | CHALONG VILLAGE,9.5 KM S OF PHUKET | PHUKET STATE | THAILAND |

APPENDIX J. ASIA, AFRICA, AND AUSTRALIA SITES OF RAKE AND BERLESE COLLECTIONS FROM PLANTS OTHER THAN HYDRILLA (1981 - 1983)

| COLL_NO | SAMPLE METHOD | HOSTPLANT | DATE | SITE | LOCATION | STATE | COUNTRY |
|---|---|---|---|---|---|---|---|
| NTR82601 | RAKE | NAJAS TENIFOLIA | 04OCT1982 | FOGG DAM | 15 KM NE OF HUMPTY DOO | NORTHERN TERRITORY | AUSTRALIA |
| NTR82602 | RAKE | UTRICULARIA | 06OCT1982 | ISLING BILLABONG | 15 KM N OF JAHIRU | NORTHERN TERRITORY | AUSTRALIA |
| NTR82901 | RAKE | NYMPHOIDES | 04OCT1982 | FOGG DAM | 15 KM NE OF HUMPTY DOO | NORTHERN TERRITORY | AUSTRALIA |
| NTR82902 | RAKE | NYMPHAEA GIGANTEA | 06OCT1982 | ISLIND BILLABONG | 15 KM N OF JABIRU | NORTHERN TERRITORY | AUSTRALIA |
| NTR82903 | RAKE | LUDWIGIA ASCENDENS | 06OCT1982 | ISLIND BILLABONG | 15 KM N OF JABIRU | NORTHERN TERRITORY | AUSTRALIA |
| BUR81801 | RAKE | ALTERNANTHERA | 10JUL1981 | INYA LAKE | WASHINGTON PARK,RANGOON | RANGOON DIVISION | BURMA |
| BUR83321 | BRLESE | NAJAS | 18SEP1983 | MANDALAY MOAT | FORT MANDALAY | MANDALAY DIVISION | BURMA |
| KAR82601 | BRLESE | POTAMOGETON | 11MAY1982 | DASAPPADODDI POND | 35.5 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82602 | BRLESE | POTAMOGETON | 20MAY1982 | MEDAHALLI WELL | 15 KM E OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82701 | BRLESE | NAJAS MINOR | 11MAY1982 | DASAPPADODDI POND | 35.5 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82702 | BRLESE | NAJAS MINOR | 11MAY1982 | OSUKKRE POND | 23.1 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82703 | BRLESE | NAJAS MINOR | 11MAY1982 | DASAPPADODDI POND | 35.5 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82704 | BRLESE | NAJAS GRAMINEA | 20MAY1982 | HOSKOTTE KERE | PADDY FIELD 35 KM E OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82801 | BRLESE | CHARA SPECIES | 20MAY1982 | MEDAHALLI WELL | 15 KM E OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82901 | RAKE | NYMPHAEA PUBESCENS | 07MAY1982 | DASAPPADODDI POND | 35.5 KM WSW OF BANGALORE | KARNATAKA STATE | INDIA |
| KAR82902 | BRLESE | MARSELIA MINUTA | 25MAY1982 | ARKAVARTI STREAM | 19.5 KM SE OF BANGALORE | KARNATAKA STATE | INDIA |
| KAS83501 | RAKE | MYRIOPH SPICATUM | 10OCT1983 | NAGIN LAKE | SRINAGAR | KASHMIR STATE | INDIA |
| KAS83421 | BRLESE | POTAMOGETON | 06OCT1983 | DAL LAKE | 5 KM N OF SRINAGAR | KASHMIR STATE | INDIA |
| KAS83521 | BRLESE | MYRIOPH SPICATUM | 02OCT1983 | NAGIN LAKE | SRINAGAR | KASHMIR STATE | INDIA |
| KAS83621 | BRLESE | CERATOPHYLLUM | 10OCT1983 | DAL LAKE | 5 KM N OF SRINAGAR | KASHMIR STATE | INDIA |
| SUL82801 | RAKE | OTTELIA | 03SEP1982 | LAKE LAMPULUNG | 5 KM NE OF SENGKANG | SE SULAWESI | INDONESIA |
| SUM81501 | RAKE | MYRIOPH SPICATUM | 11SEP1981 | LAKE TOBA | E SHORE OF SAMOSIR ISLAND | NORTH SUMATRA | INDONESIA |
| SUM81502 | RAKE | MYRIOPH SPICATUM | 12SEP1981 | LAKE TOBA | E SHORE OF SAMOSIR ISLAND | NORTH SUMATRA | INDONESIA |
| SUM81801 | RAKE | POTAMOGETON | 12SEP1981 | LAKE TOBA | NE SHORE OF SAMOSIR ISLAND | NORTH SUMATRA | INDONESIA |
| SUM81802 | RAKE | POTAMOGETON | 14SEP1981 | LAKE TOBA | SE END OF SAMOSIR ISLAND | NORTH SUMATRA | INDONESIA |
| KEN82101 | RAKE | AZOLLA | 27APR1982 | LAKE VICTORIA | NYAKCH BAY, KIUSA VILLAGE | NYANZA PROVINCE | KENYA |
| KEN82601 | RAKE | POTAMOGETON | 27APR1982 | LAKE VICTORIA | NYAKCH BAY, KIUSA VILLAGE | NYANZA PROVINCE | KENYA |
| KEN82602 | RAKE | POTAMOGETON | 28APR1982 | LAKE VICTORIA | ASEMBO BAY VILLAGE | NYANZA PROVINCE | KENYA |
| KEN82702 | RAKE | NAJAS PECTINATUS | 28APR1982 | LAKE VICTORIA | ASEMBO BAY, ALLERO BEACH | NYANZA PROVINCE | KENYA |
| PEN82101 | RAKE | PISTIA STRATIOTES | 30JUL1982 | ROADSIDE CANAL | 10 KM N OF BUTTERWORTH | PENANG STATE | MALAYSIA |
| PRK82101 | RAKE | PISTIA STRATIOTES | 06JUN1982 | STREAM | SIMPANG EMPAT VILLAGE | PERAK STATE | MALAYSIA |
| PAP83001 | RAKE | MIXED | 14JUL1983 | LEA LEA LAKE | 40 KM N OF PORT MORESBY | CENTRAL PROVINCE | NEW GUINEA |
| PAP83101 | RAKE | SALVINIA MOLESTA | 22JUL1983 | SEPIK RIVER | ANGORAM VILLAGE | E.SEPIK PROVINCE | NEW GUINEA |
| LAN82901 | RAKE | NYMPHAEA STELLATA | 06JUN1982 | SELLANKANDAL POND | 6 KM E OF PUTTALAM | NORTHWESTERN PROV. | SRI LANKA |
| LAN82902 | RAKE | IPOMEA AQUATICA | 06JUN1982 | SELLANKANDAL POND | 6 KM E OF PUTTALAM | NORTHWESTERN PROV. | SRI LANKA |
| PHK82901 | RAKE | NYMPHOIDES | 23JUL1982 | IRRIGATION POND | CHALONG VILLAGE,9.5 KM S OF PHUKET | PHUKET STATE | THAILAND |

APPENDIX K. BIOMASS AND FAUNAL NUMBERS OF PLANT SAMPLES COLLECTED IN ASIA AND AUSTRALIA (1981 - 1983)

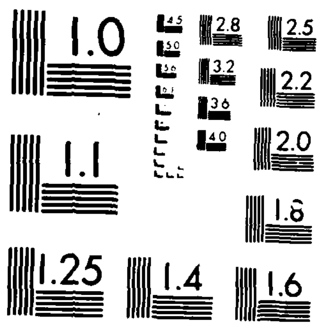
| COUNTRY | COLLECTION NUMBER | HOSTPLANT | WET WEIGHT G | DRY WEIGHT G | NUMBER OF INSECTS | NUMBER OF CRUSTACEANS | NUMBER OF SNAILS | NUMBER OF MITES | NUMBER OF WORMS |
|---|---|---|---|---|---|---|---|---|---|
| AUSTRALIA | NTR82201 | HYDRILLA | 390.0 | . | 24 | 0 | 5 | 0 | 0 |
| AUSTRALIA | NTR82202 | HYDRILLA | 270.0 | . | 13 | 0 | 0 | 0 | 0 |
| AUSTRALIA | NTR82203 | HYDRILLA | 450.0 | . | 19 | 0 | 1 | 0 | 0 |
| AUSTRALIA | NTR82601 | NAJAS | 175.0 | . | 6 | 0 | 18 | 0 | 0 |
| AUSTRALIA | NTR82602 | UTRICULARIA | 450.0 | . | 0 | 0 | 0 | 0 | 0 |
| AUSTRALIA | NTR82901 | NYMPHOIDES | 170.0 | . | 2 | 0 | 3 | 0 | 0 |
| AUSTRALIA | NTR82902 | NYMPHAEA | 195.0 | . | 2 | 0 | 0 | 0 | 0 |
| AUSTRALIA | NTR82903 | LUDWIGIA | 225.0 | . | 2 | 0 | 0 | 0 | 0 |
| AUSTRALIA | NTR83201 | HYDRILLA | 140.0 | . | 59 | 4 | 12 | 0 | 2 |
| AUSTRALIA | NTR83202 | HYDRILLA | 200.0 | . | 31 | 1 | 3 | 0 | 0 |
| AUSTRALIA | NTR83221 | HYDRILLA | 1620.0 | 100.0 | 65 | 0 | 10 | 0 | 0 |
| AUSTRALIA | NTR83222 | HYDRILLA | 985.0 | 85.0 | 103 | 0 | 1 | 5 | 0 |
| AUSTRALIA | QLD82201 | HYDRILLA | 380.0 | . | 0 | 15 | 1 | 0 | 0 |
| AUSTRALIA | QLD82202 | HYDRILLA | 510.0 | . | 25 | 0 | 0 | 0 | 0 |
| AUSTRALIA | QLD82203 | HYDRILLA | 310.0 | . | 40 | 0 | 3 | 0 | 0 |
| AUSTRALIA | QLD82204 | HYDRILLA | 365.0 | . | 1 | 1 | 0 | 0 | 0 |
| AUSTRALIA | QLD83201 | HYDRILLA | 290.0 | . | 1 | 0 | 0 | 0 | 0 |
| AUSTRALIA | QLD83202 | HYDRILLA | 450.0 | . | 13 | 2 | 0 | 1 | 0 |
| AUSTRALIA | QLD83221 | HYDRILLA | 555.0 | 55.0 | 2 | 0 | 0 | 0 | 0 |
| AUSTRALIA | QLD83222 | HYDRILLA | 260.0 | 18.0 | 5 | 0 | 0 | 1 | 0 |
| BURMA | BUR81201 | HYDRILLA | . | . | 0 | 0 | 32 | 0 | 0 |
| BURMA | BUR81202 | HYDRILLA | . | . | 0 | 0 | 4 | 0 | 0 |
| BURMA | BUR81801 | ALTERNANTHERA | . | . | 10 | 0 | 0 | 0 | 0 |
| BURMA | BUR82201 | HYDRILLA | 390.0 | . | 0 | 0 | 7 | 0 | 0 |
| BURMA | BUR82202 | HYDRILLA | 340.0 | . | 10 | 0 | 54 | 0 | 0 |
| BURMA | BUR82203 | HYDRILLA | 270.0 | . | 6 | 0 | 16 | 0 | 0 |
| BURMA | BUR82204 | HYDRILLA | 350.0 | . | 5 | 3 | 50 | 0 | 0 |
| BURMA | BUR82205 | HYDRILLA | . | . | 35 | 10 | 5 | 0 | 0 |
| BURMA | BUR82206 | HYDRILLA | 509.0 | . | 1 | 1 | 27 | 0 | 0 |
| BURMA | BUR83201 | HYDRILLA | 465.0 | . | 25 | 10 | 213 | 0 | 0 |
| BURMA | BUR83202 | HYDRILLA | 455.0 | . | 4 | 0 | 24 | 1 | 0 |
| BURMA | BUR83203 | HYDRILLA | 280.0 | . | 4 | 1 | 9 | 0 | 0 |
| BURMA | BUR83221 | HYDRILLA | 630.0 | 110.0 | 3 | 0 | 23 | 0 | 0 |
| BURMA | BUR83222 | HYDRILLA | 505.0 | 50.0 | 5 | 0 | 54 | 0 | 0 |
| BURMA | BUR83223 | HYDRILLA | 320.0 | 40.0 | 1 | 2 | 3 | 0 | 0 |
| BURMA | BUR83321 | NAJAS | 550.0 | 45.0 | 63 | 2 | 24 | 2 | 0 |
| INDIA | KAR81201 | HYDRILLA | . | . | 15 | 0 | 8 | 0 | 0 |
| INDIA | KAR81202 | HYDRILLA | . | . | 4 | 0 | 12 | 0 | 0 |
| INDIA | KAR81203 | HYDRILLA | . | . | 5 | 1 | 2 | 0 | 0 |
| INDIA | KAR81204 | HYDRILLA | . | . | 1 | 0 | 1 | 0 | 0 |
| INDIA | KAR81205 | HYDRILLA | . | . | 9 | 0 | 24 | 0 | 0 |
| INDIA | KAR81206 | HYDRILLA | . | . | 3 | 0 | 1 | 0 | 0 |
| INDIA | KAR82201 | HYDRILLA | 690.0 | . | 59 | 0 | 45 | 0 | 0 |
| INDIA | KAR82202 | HYDRILLA | 715.0 | . | 17 | 2 | 7 | 0 | 0 |
| INDIA | KAR82203 | HYDRILLA | . | . | 44 | 0 | 5 | 0 | 2 |
| INDIA | KAR82204 | HYDRILLA | . | . | 18 | 0 | 0 | 0 | 0 |
| INDIA | KAR82205 | HYDRILLA | 250.0 | 23.0 | 28 | 0 | 26 | 2 | 0 |
| INDIA | KAR82206 | HYDRILLA | 250.0 | 33.0 | 18 | 0 | 36 | 1 | 1 |
| INDIA | KAR82207 | HYDRILLA | 250.0 | 27.0 | 29 | 0 | 0 | 0 | 0 |
| INDIA | KAR82601 | POTAMOGETON | 310.0 | . | 8 | 0 | 49 | 0 | 0 |
| INDIA | KAR82602 | POTAMOGETON | 500.0 | 49.0 | 91 | 0 | 5 | 0 | 0 |
| INDIA | KAR82701 | NAJAS | 750.0 | . | 13 | 6 | 8 | 0 | 0 |
| INDIA | KAR82702 | NAJAS | . | . | 41 | 0 | 10 | 0 | 3 |
| INDIA | KAR82703 | NAJAS | . | 70.0 | 686 | 0 | 1 | 0 | 0 |
| INDIA | KAR82704 | NAJAS | 250.0 | 23.0 | 27 | 0 | 101 | 0 | 0 |

APPENDIX K CONTINUED.

| COUNTRY | COLLECTION NUMBER | HOSTPLANT | WET WEIGHT G | DRY WEIGHT G | NUMBER OF INSECTS | NUMBER OF CRUSTACEANS | NUMBER OF SNAILS | NUMBER OF MITES | NUMBER OF WORMS |
|---|---|---|---|---|---|---|---|---|---|
| INDIA | KAR82801 | CHARA | 250.0 | . | 0 | 0 | 0 | 0 | 0 |
| INDIA | KAR82901 | NYMPHAEA | 845.0 | . | 2 | 0 | 26 | 0 | 0 |
| INDIA | KAR82902 | MARSELIA | 250.0 | 25.0 | 12 | 0 | 0 | 0 | 0 |
| INDIA | KAS83201 | HYDRILLA | 260.0 | . | 0 | 0 | 0 | 0 | 0 |
| INDIA | KAS83202 | HYDRILLA | 260.0 | . | 2 | 0 | 0 | 0 | 0 |
| INDIA | KAS83203 | HYDRILLA | . | . | 0 | 0 | 0 | 0 | 0 |
| INDIA | KAS83501 | MYRIOPHYLLUM | 263.0 | . | 0 | 0 | 0 | 0 | 0 |
| INDIA | KAS83221 | HYDRILLA | 500.0 | 45.0 | 9 | 0 | 1 | 0 | 0 |
| INDIA | KAS83223 | HYDRILLA | 250.0 | 38.0 | 1 | 0 | 1 | 0 | 0 |
| INDIA | KAS83224 | HYDRILLA | . | . | 0 | 0 | 1 | 0 | 0 |
| INDIA | KAS83421 | POTAMOGETON | 250.0 | 45.0 | 1 | 0 | 1 | 0 | 0 |
| INDIA | KAS83521 | MYRIOPHYLLUM | 500.0 | 110.0 | 5 | 0 | 0 | 0 | 2 |
| INDIA | KAS83621 | CERATOPHYLLUM | 250.0 | . | 2 | 0 | 1 | 0 | 0 |
| INDONESIA | BAL83201 | HYDRILLA | 375.0 | . | 1 | 0 | 35 | 0 | 0 |
| INDONESIA | BAL83221 | HYDRILLA | 670.0 | 38.0 | 1 | 0 | 24 | 0 | 0 |
| INDONESIA | JAV81201 | HYDRILLA | 688.9 | 48.9 | 32 | 0 | 12 | 0 | 0 |
| INDONESIA | JAV81202 | HYDRILLA | 566.0 | 49.9 | 1 | 4 | 0 | 0 | 0 |
| INDONESIA | JAV81203 | HYDRILLA | 833.0 | 102.0 | 6 | 1 | 5 | 0 | 0 |
| INDONESIA | JAV81204 | HYDRILLA | . | 58.0 | 151 | 0 | 82 | 0 | 0 |
| INDONESIA | JAV81205 | HYDRILLA | 499.0 | 35.0 | 21 | 0 | 15 | 0 | 0 |
| INDONESIA | JAV81206 | HYDRILLA | 666.0 | 70.5 | 1 | 0 | 6 | 0 | 0 |
| INDONESIA | LOM82201 | HYDRILLA | 360.0 | . | 10 | 0 | 4 | 0 | 1 |
| INDONESIA | SUL82201 | HYDRILLA | 495.0 | . | 92 | 1 | 15 | 0 | 0 |
| INDONESIA | SUL82202 | HYDRILLA | 370.0 | . | 7 | 0 | 40 | 0 | 0 |
| INDONESIA | SUL82801 | OTTELIA | 190.0 | . | 4 | 2 | 14 | 0 | 0 |
| INDONESIA | SUM81201 | HYDRILLA | . | 46.5 | 12 | 5 | 19 | 0 | 0 |
| INDONESIA | SUM81202 | HYDRILLA | 813.0 | 88.0 | . | 0 | 10 | 0 | 0 |
| INDONESIA | SUM81203 | HYDRILLA | 967.0 | 69.0 | 3 | 0 | 2 | 0 | 0 |
| INDONESIA | SUM81204 | HYDRILLA | 1890.0 | 72.5 | 20 | 8 | 15 | 0 | 0 |
| INDONESIA | SUM81205 | HYDRILLA | 1800.0 | 93.0 | 7 | 0 | 12 | 0 | 0 |
| INDONESIA | SUM81501 | MYRIOPHYLLUM | 1267.0 | 98.0 | 0 | 0 | 0 | 0 | 6 |
| INDONESIA | SUM81502 | MYRIOPHYLLUM | 669.0 | 326.0 | 0 | 0 | 1 | 0 | 0 |
| INDONESIA | SUM81801 | POTAMOGETON | 971.0 | 156.0 | 1 | 0 | 0 | 0 | 0 |
| INDONESIA | SUM81802 | POTAMOGETON | . | 85.5 | 0 | 0 | 0 | 0 | 0 |
| KENYA | KEN82101 | AZOLLA | . | . | 11 | 4 | 0 | 0 | 1 |
| KENYA | KEN82601 | POTAMOGETON | . | . | 38 | 0 | 40 | 0 | 7 |
| KENYA | KEN82602 | POTAMOGETON | . | . | 218 | 0 | 1 | 0 | 11 |
| KENYA | KEN82701 | NAJAS | . | . | 0 | 0 | 0 | 0 | 0 |
| KENYA | KEN82702 | NAJAS | . | . | 44 | 1 | 31 | 0 | 0 |
| MALAYSIA | PEN81201 | HYDRILLA | . | . | 2 | 0 | 0 | 0 | 0 |
| MALAYSIA | PEN82101 | PISTIA | . | . | 12 | 0 | 2 | 0 | 0 |
| MALAYSIA | PEN82201 | HYDRILLA | . | . | 43 | 0 | 4 | 0 | 3 |
| MALAYSIA | PEN82202 | HYDRILLA | . | . | 31 | 0 | 0 | 0 | 0 |
| MALAYSIA | PEN82203 | HYDRILLA | . | . | 35 | 4 | 3 | 0 | 9 |
| MALAYSIA | PEN82204 | HYDRILLA | . | . | 7 | 1 | 3 | 1 | 0 |
| MALAYSIA | PEN82205 | HYDRILLA | . | . | 2 | 0 | 0 | 0 | 0 |
| MALAYSIA | PEN83201 | HYDRILLA | 285.0 | . | 3 | 0 | 17 | 0 | 0 |
| MALAYSIA | PEN83221 | HYDRILLA | 600.0 | 38.0 | 31 | 2 | 25 | 1 | 0 |

AD-A165 419 OVERSEAS SURVEYS (1981-1983) FOR INSECTS TO CONTROL HYDRILLA(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS ENVIRONMENTAL LAB J K BALCIUNAS DEC 85 2/2

UNCLASSIFIED WES/TR/A-85-4 F/G 13/2 NL




MICROCOPY RESOLUTION TEST CHART

APPENDIX K CONTINUED.

| COUNTRY | COLLECTION NUMBER | HOSTPLANT | WET WEIGHT G | DRY WEIGHT G | NUMBER OF INSECTS | NUMBER OF CRUSTACEANS | NUMBER OF SNAILS | NUMBER OF MITES | NUMBER OF WORMS |
|---|---|---|---|---|---|---|---|---|---|
| MALAYSIA | PRK82101 | PISTIA | . | . | 40 | 0 | 0 | 0 | 0 |
| MALAYSIA | PRK82201 | HYDRILLA | . | . | 4 | 0 | 38 | 0 | 1 |
| MALAYSIA | PRK82202 | HYDRILLA | . | . | 2 | 0 | 3 | 1 | 0 |
| MALAYSIA | PRK82204 | HYDRILLA | . | . | 0 | 0 | 8 | 0 | 8 |
| MALAYSIA | PRK82205 | HYDRILLA | . | . | 0 | 0 | 10 | 0 | 0 |
| MALAYSIA | PRK82206 | HYDRILLA | . | . | 17 | 0 | 0 | 0 | 0 |
| MALAYSIA | PRK82207 | HYDRILLA | . | . | 3 | 0 | 0 | 0 | 0 |
| MALAYSIA | PRK82208 | HYDRILLA | . | . | 65 | 0 | 0 | 1 | 0 |
| MALAYSIA | PRK82209 | HYDRILLA | . | . | 11 | 0 | 1 | 0 | 0 |
| MALAYSIA | PRK82210 | HYDRILLA | . | . | 28 | 2 | 2 | 0 | 0 |
| MALAYSIA | PRK82211 | HYDRILLA | . | . | 54 | 1 | 7 | 0 | 0 |
| MALAYSIA | PRK82212 | HYDRILLA | . | . | 11 | 0 | 0 | 0 | 0 |
| MALAYSIA | PRK83201 | HYDRILLA | . | . | 202 | 0 | 0 | 0 | 0 |
| MALAYSIA | PRK83202 | HYDRILLA | . | . | 36 | 0 | 0 | 0 | 1 |
| MALAYSIA | PRK83203 | HYDRILLA | . | . | 322 | 0 | 0 | 0 | 0 |
| NEW GUINEA | PAP83201 | HYDRILLA | 185.0 | . | 0 | 0 | 0 | 0 | 0 |
| NEW GUINEA | PAP83202 | HYDRILLA | 480.0 | . | 0 | 0 | 0 | 0 | 0 |
| NEW GUINEA | PAP83203 | HYDRILLA | 350.0 | . | 1 | 0 | 41 | 0 | 0 |
| NEW GUINEA | PAP83204 | HYDRILLA | 400.0 | . | 0 | 0 | 0 | 0 | 0 |
| NEW GUINEA | PAP83205 | HYDRILLA | 360.0 | . | 50 | 0 | 5 | 0 | 0 |
| NEW GUINEA | PAP83206 | HYDRILLA | 620.0 | . | 119 | 0 | 24 | 0 | 0 |
| NEW GUINEA | PAP83001 | MIXED | . | . | 6 | 0 | 0 | 0 | 0 |
| NEW GUINEA | PAP83101 | SALVINIA | 1000.0 | . | 26 | 0 | 0 | 0 | 0 |
| NEW GUINEA | PAP83221 | HYDRILLA | 400.0 | 32.0 | 1 | 0 | 0 | 0 | 0 |
| NEW GUINEA | PAP83222 | HYDRILLA | 403.0 | 35.0 | 0 | 0 | 4 | 50 | 22 |
| NEW GUINEA | PAP83223 | HYDRILLA | 360.0 | 40.0 | 2 | 0 | 39 | 0 | 0 |
| NEW GUINEA | PAP83224 | HYDRILLA | 445.0 | 125.0 | 4 | 0 | 2 | 0 | 0 |
| NEW GUINEA | PAP83225 | HYDRILLA | 335.0 | 85.0 | 9 | 0 | 0 | 0 | 0 |
| NEW GUINEA | PAP83226 | HYDRILLA | 265.0 | 45.0 | 20 | 0 | 0 | 0 | 0 |
| PHILIPPINES | LUZ83201 | HYDRILLA | 515.0 | . | 1 | 0 | 15 | 0 | 1 |
| PHILIPPINES | LUZ83202 | HYDRILLA | 300.0 | . | 2 | 3 | 16 | 0 | 0 |
| PHILIPPINES | LUZ83221 | HYDRILLA | 505.0 | 70.0 | 6 | 3 | 3 | 0 | 0 |
| PHILIPPINES | LUZ83222 | HYDRILLA | 570.0 | 39.0 | 9 | 5 | 4 | 0 | 0 |
| PHILIPPINES | MDN83201 | HYDRILLA | 375.0 | . | 10 | 0 | 1 | 0 | 0 |
| PHILIPPINES | MDN83202 | HYDRILLA | 485.0 | . | 14 | 0 | 0 | 0 | 0 |
| PHILIPPINES | MDN83221 | HYDRILLA | 300.0 | 20.0 | 26 | 0 | 0 | 0 | 0 |
| PHILIPPINES | MDN83222 | HYDRILLA | 405.0 | 45.0 | 7 | 0 | 0 | 0 | 0 |
| PHILIPPINES | MDN83223 | HYDRILLA | 400.0 | 46.0 | 66 | 0 | 0 | 0 | 0 |
| SRI LANKA | LAN82201 | HYDRILLA | 460.0 | . | 5 | 0 | 16 | 0 | 3 |
| SRI LANKA | LAN82202 | HYDRILLA | 435.0 | . | 10 | 0 | 200 | 0 | 1 |
| SRI LANKA | LAN82203 | HYDRILLA | 275.0 | . | 5 | 0 | 20 | 0 | 0 |
| SRI LANKA | LAN82204 | HYDRILLA | 420.0 | . | 15 | 7 | 34 | 0 | 1 |
| SRI LANKA | LAN82205 | HYDRILLA | 635.0 | . | 1 | 0 | 5 | 0 | 1 |
| SRI LANKA | LAN82901 | NYMPHAEA | . | . | 9 | 0 | 27 | 0 | 0 |
| SRI LANKA | LAN82902 | IPOMEA | . | . | 1 | 0 | 0 | 0 | 0 |
| THAILAND | PHK82201 | HYDRILLA | 265.0 | . | 6 | 0 | 164 | 0 | 0 |
| THAILAND | PHK82202 | HYDRILLA | 510.0 | . | 0 | 0 | 0 | 0 | 0 |

END
FILMED
4-86
DTIC